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H. H. Brown, Editor
L. S. Blodgett, Managing Editor
Warner Lumbard, Associate Editor

James Swan, Contributing Editor

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Annual Index

THE annual index of Marine Engineering and Shipping Age for the year 1928 will be published separately from the magazine before the end of this month. As the complete index will be useful only to those who have kept a complete file of the magazine for the year, only a sufficient number of copies will be printed to meet the requirements of readers who notify us of their desire for a copy.

A copy of the annual index will be mailed without cost to each subscriber whose request for it is received at our New York office on or before January 1, 1929.

The Naval Architects' Meeting

INTEREST in the naval architects' meeting last month was heightened by the general feeling of optimism that prevails in the shipbuilding and shipping industries at present over the better prospects for business during the coming year. Naval architects in this country now have an opportunity to design and build a considerable number of relatively large and fast combination passenger and cargo vessels for overseas service in highly competitive trades. The ships must be economical to build and economical to operate. For this reason the papers read and discussed at the naval architects' meeting dealing with improved propelling machinery were of particular interest and value. Captain Gatewood's paper giving data on the performance of the Shipping Board's converted motorships was particularly welcome in this respect as it will give shipowners greater confidence in considering this type of propulsion. The papers giving the results obtained with several different types of ships equipped with turbine-electric drive point the way towards attaining more economical steam propulsion and those dealing with the problem of burning coal both in powdered form and by means of mechanical stokers mark a progressive step in this direction. The society is to be congratulated for its valuable and timely contributions toward the solution of this perplexing problem.

Stability Report Adopted

AT the regular meeting of the executive board of the American Marine Standards Committee held in New York on November 17, the final report of the special committee on stability and loading of ships was adopted as recommended practice. The report applies only to new passenger ships. As soon as it is printed it will be available to all those interested in the design and operation of this class of vessels. The rules and regulations embodied in this report are the result of four years of painstaking and unremitting labor on the part of the special committee entrusted with this difficult undertaking and their adoption marks one of the most important and far-reaching achievements of the American Marine Standards Committee. The special committee responsible for this report was composed of representatives of the American Marine Standards Committee, the United States Department of Commerce, the American Steamship Owners' Association, the Neptune Association, the National Council of American Shipbuilders, the Society of Naval Architects and Marine Engineers, the American Bureau of Shipping and the New York Board of Underwriters. Thus every important interest concerned with shipping in the United States had a part in framing these regulations. Furthermore, the preliminary report of this committee, issued two years ago, was submitted for criticism to everyone in this country and abroad at all concerned with the subject, so that the final report is based on criticisms and suggestions from the most authoritative sources in the world. The application of these rules and regulations in practice will be one of the best safeguards that can be devised against such disasters

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at sea as the recent sinking of the *Vestris* and it is to be hoped that the report will be given the force of law by adoption as a part of the rules and regulations of the United States Steamboat Inspection Service.

New Operators' Agreements

NEW forms of agreements including the conditions and terms under which operators of Shipping Board vessels work and are paid were adopted by the Shipping Board on November 13, and the Merchant Fleet Corporation was instructed to put them into effect as expeditiously as possible. The purpose is to increase the responsibility of the managing operators, reduce the supervision of the Fleet Corporation and reduce the government's losses on account of ship operation. Estimates of the savings that may be effected under the new agreements range as high as $5,000,000 a year.

The agreements under which the Fleet Corporation has indirectly operated the government fleet with the exception of the United States Lines has been revised from time to time on a percentage basis and officials of the Fleet Corporation have been working on a revision of the present form of agreement for several months.

Two plans have been developed in the corporation, one known as the "Lump-Sum Plan" and the other as the "Profit Sharing Plan." Both would reduce the supervisory requirements to merely an inspection and auditing force and would place the board's reduced ship operations more nearly on a private basis and stimulate private initiative by placing responsibility on the operator, according to a statement issued by the board explaining the new plans.

The "Lump-Sum Plan" would involve changing the compensation of the operator from the present percentage basis to a lump sum amount per annum, for which he is to maintain the line, the Shipping Board making adequate inspections from time to time covering the regular maintenance of the service and the physical condition of the ships. The amount of lump sum compensation will be arrived at from an analysis of the present results in the particular line, and the agreement will provide that the amount to be paid shall be subject to adjustment from time to time.

The "Profit Sharing Plan" is designed to set up an incentive for the agent to minimize operating costs in addition to the incentive already existing under the present agreement to increase gross revenues. The plan contemplates fixing with the particular operator a minimum amount of compensation which is required to meet his necessary out-of-pocket expenses. Thereafter, his compensation would depend solely upon net operating results. This will be accomplished by fixing a definite percentage on gross receipts which will maintain the present incentive for the operator to secure all possible revenue. An offsetting percentage based upon the extent to which the operator will participate in operating costs will be deducted from his percentage share of the gross revenue. This would result in making any substantial profit to the operator dependent upon the increase in gross revenue and the decrease in operating costs.

It is confidently anticipated by the board that either of these plans where adopted with the different operators will result in greater efficiency in the operation of the lines and reduce losses. The purpose in general is to give the operator a freer hand in the development of the line and at the same time fix a responsibility for reducing the operating costs, so that an efficient operator will secure better results from his own efforts and in the final analysis help build up the business for each established line.

Lloyd's Annual Report

AS is always the case, the annual report of Lloyd's Register of Shipping makes interesting and instructive reading. It covers the period from June 30, 1927, to June 30, 1928. During this period 578 new vessels of 1,885,533 gross tons were classed by Lloyd's as compared with 323 of 978,146 tons during the preceding year. While the increase in new tonnage classed amounts to approximately 93 percent, it is noted that this renewal of shipbuilding activity has evidently passed its crest, as there has been a heavy falling off in the number of vessels ordered during the year, this tendency being particularly marked in Great Britain and Ireland.

Of all the various data recorded, undoubtedly the most interesting and impressive are those relating to motorships. We, in this country, have had—owing to the almost complete cessation of merchant shipbuilding—little opportunity to observe, at first hand, as it were, the phenomenal growth of the marine heavy-oil internal combustion engine. We must turn our attention abroad to obtain a fair comprehension of this tremendous development.

As was to be expected, of the total of power-propelled vessels which are recorded in Lloyd's latest report, the vast majority are steamers; something over 91 percent of the total of over 65 million gross tons of existing vessels of 100 tons and over having the older type of propelling machinery. But when we turn to the record of vessels classed during the past year, quite another story is found. Of a total of 1,875,068 gross tons of new power vessels classed, 812,437 gross tons, or over 43 percent, are motorships. In the period 1924-1925, this percentage was 23!

Even more impressive is the statement that during the past year, 16 motorships of from 9,000 to 32,000 gross tons have been classed; and, further, that there are now being constructed, under Lloyd's survey, 17 sets of double-acting Diesel engines, having an aggregate indicated horsepower of 180,000, which would seem a fairly illuminating answer to the question of the practicability of this type of engine for large powers.

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An increasing demand for oil tankers is evidenced by the classification, during the past year, of 102 ships of this type, having a total gross tonnage of 587,491 and including the largest tanker yet built—a motorship of 16,436 tons. When one considers the increase in the number of motorships, and also the fact that of the new steamers classed during the year over 40 percent were fitted for burning fuel oil, the demand for tank ships is, perhaps, not surprising.

The largest single bill to be met in ship operation is that for fuel, and one finds that this item receives considerable attention. Of all power tonnage afloat of 100 tons and over, 62.4 percent still employs coal only for fuel. In this connection, the development of pulverized-coal burning is referred to as receiving the closest attention of the society. The commercial success of motorships and, in greater degree, of oil-burning steamers is to a very considerable extent dependent upon the relative price of coal and oil. For Great Britain, particularly, any development tending to increase the efficiency of coal-burning ships is a matter of the utmost importance. While it is still too early to look for a thoroughly convincing demonstration of the possibilities of powdered coal on shipboard, it seems certain that another year will serve to make clear its relative weight as a factor in the problem of commercial ship operation.

Of something over one million gross tons of steamers built during the year, 80 percent are propelled by reciprocating engines. In this connection, the statement that a large number of vessels are being constructed in which this type of engine has combined with it a low-pressure turbine, geared to the shaft, is interesting and suggestive. The triple-expansion engine has thoroughly earned its popularity, and if, as seems to be the case, the Bauer-Wach system materially increases its economy of operation, this popularity is likely to continue for many years to come.

Another interesting section of the report is devoted to refrigerator ships. Sixty-two refrigerating installations, having a total insulated capacity of nearly 5½ million cubic feet, were fitted up during the year under the society's supervision. Internal-combustion machinery is peculiarly suited to this class of vessel, so one finds that the five largest installations, ranging from 416,000 to 570,000 cubic feet, are in motor-driven ships.

Among the many and various questions which the society's technical committee has under consideration is the effect of ballasting on ships at sea. The increased speed of cargo vessels, and the long voyages in ballast condition which often have to be undertaken, make this a matter of importance; and so a member of the technical staff has been detailed to make voyages on cargo ships, with the object of observing the behavior of their structure under severe conditions of weather and loading—an example of the thoroughness of Lloyd's methods of work, and their unswerving determination to keep fully abreast of every new condition which arises.

It has been possible here to touch on but a few of the many lines of thought which this report suggests. They are too numerous to mention in detail, and one can only state that everyone, even though remotely connected with shipping, will find well repaid the time he may spend in familiarizing himself with its clear and instructive pages, as they represent a most thorough survey of the world's shipping.

Corrosion

IN the discussion of corrosion in our September issue, the relation of corrosive action to the useful life of steel vessels was touched upon in a general way. It is now proposed to take up, in some detail, specific classes of deterioration in the structural hull, bearing always in mind that such a broad subject can be treated editorially only in a most superficial manner.

The condition of the shell and those structural members immediately adjacent to it give, as was mentioned in the previous article, a fair indication of a ship's age or, in other words, they may be looked to, to determine whether or not a ship is worth repairing. To even a greater extent than most other parts of a steel hull the proper preservation of shell plating is largely dependent upon the care taken of it at the very start of a ship's career; in short, during construction. All mild steel, in order to last, must be covered with some sort of protective coating—in a ship this coating is usually paint or some form of cement. In order that either of these should fulfill its mission, it must be in direct contact with the steel, no coating of rust or foreign substance will permit of firm and continued adhesion and protection. Apparently the only sure way to bring about this condition is to remove the mill scale from the steel by "pickling" in dilute hydrochloric acid. This process while commonly pursued with naval vessels, is used only to a very limited extent in merchant work because of the delay and increase in cost which are involved; but, in this connection, it should be noted that naval ships do not have the reserve of thickness and weight of material which characterize the ordinary commercial vessels. Next to pickling, the best way to ensure the removal of mill scale is to defer all painting as long as possible, allowing rust to accumulate, and finally removing this, and with it a large part of the mill scale, with wire brushes. The result so obtained is rarely entirely satisfactory as some scale almost invariably remains, only to be completely removed after several dry dockings with their accompanying cleaning, scraping and painting. Before a really impervious coating is attained, quite appreciable deterioration may, and often does, occur. The removal of mill scale by sand blasting has been suggested, but, so far as the writer is aware, this method has not been tried in shipbuilding. It would appear to have possibilities, but great care should evidently attend its use and the accumulation of sand and its final disposition certainly present problems which, to say the least, are not attractive.

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For vessels already in service, painting is a part of routine upkeep and its effectiveness will depend altogether upon the care with which it is done, assuming, of course, that first-class materials are employed. So far as the writer's experience goes, it indicates that the greatest enemy of paint, and, in consequence, of shell plating, is haste. Far too many ships are painted before the bottom is even approximately dry, and, even if the paint does adhere fairly well, its effectiveness as a real and impervious protective coating is very greatly reduced.

Turning to the inside of the ship, experience serves to show that good Portland cement, properly applied, is a very nearly perfect preservative of bottom shell plating and frames. Recently the writer had occasion to examine a shell plate which had been removed from the deadwood of an old steamer, just forward of the stern post. This plate for about half its width was protected by the cement and coke with which the inaccessible "deadwood" space had been filled. Above this, the plate was painted, or had been at one time, and was exposed to the action of bilge water and damp air. The portion in way of the cement was in perfect condition, while the upper half, between the frames, had been reduced by corrosion to approximately three-quarters of its original thickness. It is interesting to note that the portion in way of the frames had been covered with red lead before riveting up and that the contact between plate and frame had been so complete and well preserved that no water had entered and the original thickness had been maintained. It is, of course, not practicable to cover all inner portions of a steel hull, which are exposed to excessive corrosive action, with Portland cement; even if it could be done, the added weight alone would be prohibitive. Here paint comes in, or, better, bitumastic enamel or similar hard covering when such can be applied. Too much importance cannot be accorded to the fact that with bitumastic coverings, fully as much as with ordinary paints, thorough cleaning and drying are essential, before application is made.

Considering the interior of a ship, as a whole, it is evident that the work of preservation can be much lightened and at the same time made more effective by care in design, particularly of structural details and access, as far as it is possible to give it, to all parts of the steel structure. It is probable that a further development of welding, as against riveting, will contribute to this desired end. Many clips and other riveted connections often form pockets which collect moisture and dirt, where a different arrangement which it seems that welded connections would make possible will give good drainage. More than almost any other one thing, free access to all interior steel work for cleaning and painting contributes to proper maintenance and the reduction of corrosion.

Of late years the paneling and sheathing which characterized the older types of ships has been largely done away with but much, of necessity, remains. Wherever possible, this should be made portable or at least easily removable. Some woodwork in direct and permanent contact with steel there must always be and in this fact lies one of the most annoying causes of corrosion and one of the most difficult to deal with. Of all woods commonly used in shipbuilding, teak is practically alone in its neutral action upon steel. In fact it may even be credited with preservative properties, if one may judge by the usually good condition of steel decks or armor backing plates, when stripped of teak sheathing. Unfortunately teak is rather out of reach for the average mercantile ship, at any rate in this country, and other woods have to be made use of. Some varieties of oak are particularly injurious but with this exception wood in direct contact with steel appears harmful not because of any inherent property of its own, but by reason of its absorption of moisture and the difficulty of making and maintaining watertightness between the wood and the steel. Carpenter work of sufficient weight to permit of proper calking should not present great difficulties, but with joiner work it is different. Some of our American coastwise and bay steamers reveal a rather curious intermixture of steel work and joiner work, which, although giving no particular trouble when new, may become a fertile source of annoyace in an old ship. The most difficulty, in the older vessels of this class, is experienced with wood sheathing and bulkhead sills or frames laid upon the uppermost steel deck and with woodwork in the neighborhood of cargo hatches and side ports. Some working of the relatively light hulls is unavoidable, and, in consequence, water finds its way between the wood and metal, the former often remaining in a moist condition a large part of the time. Corrosion inevitably follows and usually cannot be detected until serious damage is done, only to be corrected by renewing the plate. In the more recent vessels of this class steel is taking the place of wood in lower houses and upper 'tween decks and in some cases has been extended to include passages and stateroom bulkheads to a large extent.

It has been mentioned that welding is likely to modify original construction in such a way as to reduce corrosion. In vessels already built it has already taken its place as perhaps the most important contributor to economical and effective repair and upkeep. Many plates and other structural members which but a few years ago would have of necessity been condemned and replaced can now easily be made as good as new for all practical purposes, so, to a considerable extent, corrosion is a less serious matter to deal with than once was the case. At best, however, repair by welding is a local matter and cannot be extended to rejuvenate an entire hull.

Corrosion can only be met and held in check by care—first, in design and construction, later in upkeep. So long as steel, as we now know it, continues to be the principal material of which ships are built, care alone can be relied upon to maintain the vessels in workable condition and prolong their lives.

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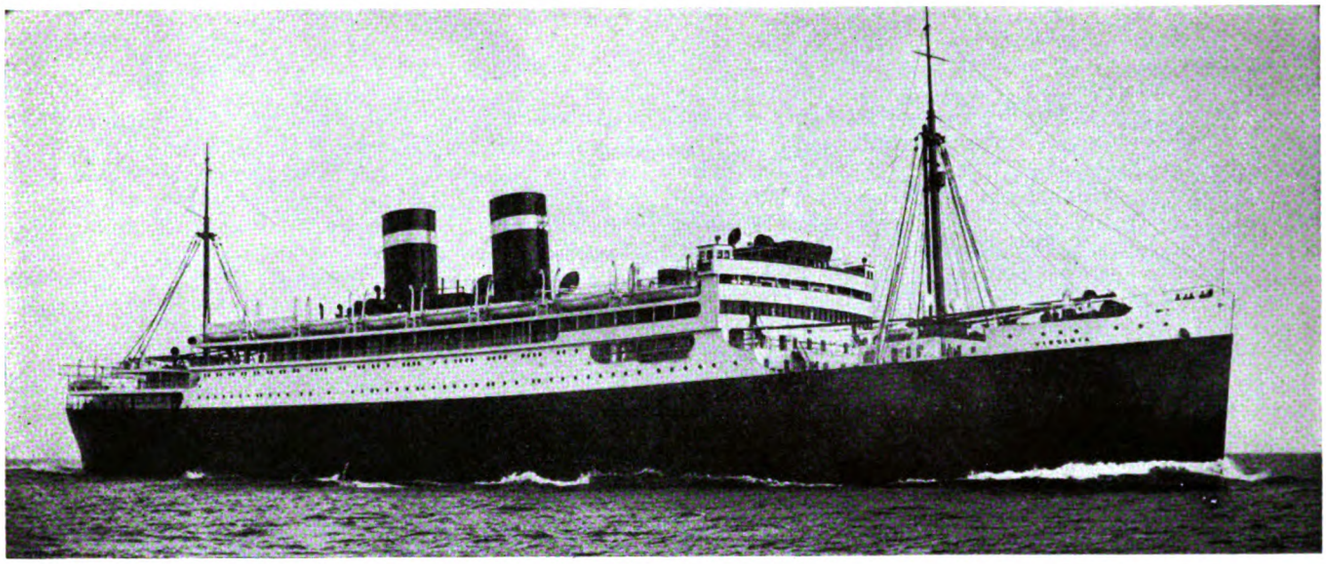


Turbo-electric drive steamship Virginia on her trial trip

Sea Trials of I. M. M. Liner Virginia

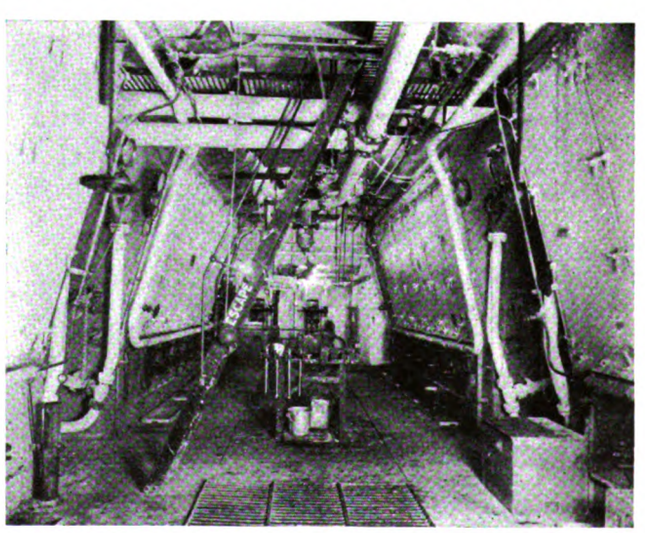
New Panama Pacific liner shows higher fuel economies than the California

THE new Panama Pacific turbo-electric liner, *Virginia,* sister ship of the *California* and the largest passenger steamship ever built in the United States, successfully completed her 140-mile sea trial on November 19, her performance coming fully up to all expectations. These trials, conducted by the builders, were completed in one day, the ship leaving the pier of the Newport News Shipbuilding and Dry-dock Company, Newport News, Va., at daylight and returning shortly after sundown. This vessel, which is owned by the Panama Pacific Line of the International Mercantile Marine Company, New York city, will make her maiden voyage on December 8 in the New York and San Francisco service.

The radio and magnetic compasses were calibrated shortly after leaving the Virginia capes and her main performance trials, consisting of four runs between the Cape Henry sea buoy and False Cape buoy, were made soon after. One run was made with the port generator connected with both motors. This was followed by a return run with the starboard generator connected with both motors. Over this course, a distance of 16⅝ miles, an average speed of about 14 knots was attained with only one generator in operation.

Two runs made with both generators connected demonstrated the ability of the vessel to attain a speed of over 18 knots. A horsepower in excess of the 17,000 shaft horsepower guaranteed was developed.

Looking forward in the lounge



View in the boiler room

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The maneuvering tests gave the vessel a turning diameter of about 700 yards. The time for the vessel to complete one turn of 360 degrees with the rudder hard over to starboard was 7 minutes 16 seconds; with a port helm the time was 7 minutes 28 seconds. The time to bring the vessel from full speed ahead to dead stop was 2 minutes 10 seconds. These tests were made on a course where the mean depth of the water is 58 feet. The ship was ballasted to a draft of 25 feet 7 inches aft and 21 feet 8 inches forward.

The fuel consumption on the *Virginia* proved to be economical from preliminary calculations. Where the *California* used 0.84 pound of oil per shaft horsepower per hour, it was estimated that the *Virginia* used 0.78 pound of oil per shaft horsepower per hour. This was due in part to the use of a higher steam pressure and a higher degree of superheat than that employed on the *California*. Steam is furnished at 300 pounds per square inch and 200 degrees F. superheat by twelve Babcock & Wilcox watertube boilers equipped with Babcock & Wilcox oil burners.

The *Virginia* is practically a duplicate of the *California*. Twelve feet have been added to the length of the *Virginia* to allow the addition of ten tourist cabin rooms and additional refrigeration space. All tourist rooms are panelled and are equipped with hot and cold running water. The refrigeration machinery space has been lengthened six feet and the three 3-inch, single-stage, Warren centrifugal pumps with their General Electric motors, which were located in the motor room on the *California*, are located in the refrigerating machinery room on the *Virginia*.

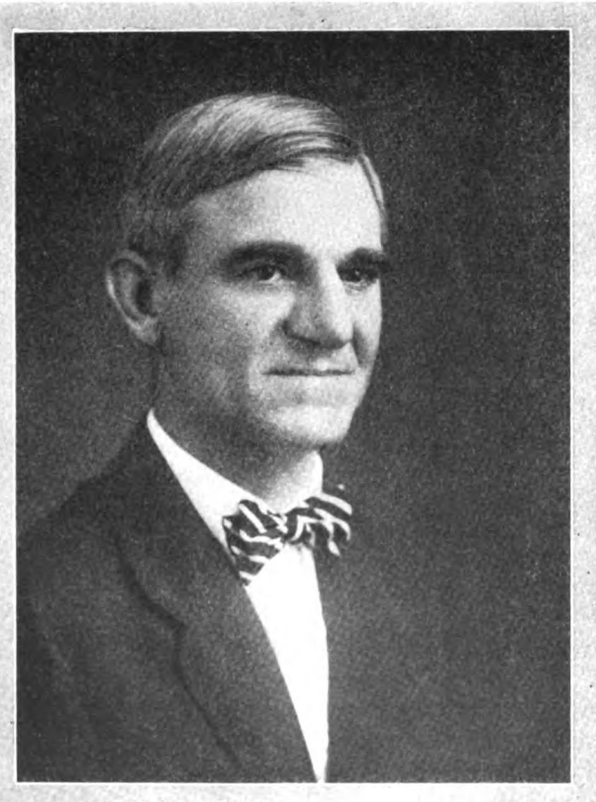
In the lounge on A deck an added spaciousness has been achieved by the increase of the height of the ceiling to twelve feet. This is an increase of about four feet over that of the *California*. The pillars have also been eliminated. The decorations of the apartment have a note of dignity. The walls are tinted in a soft shade of green with mouldings in a lighter tone and decorative panels in fresco. In the ceiling is centered a large glass dome with concealed lights which augment the soft, indirect lighting from side brackets and ceiling fixtures. Normal ventilation through large casement windows is supplemented by fans concealed behind grills over the windows. The French influence is reflected in the furniture for this room although no distinct period is followed. At one end of the room is a stage curtained in crimson damask with trimming of a golden tone to harmonize with the window draperies.

In the lounge and veranda cafe, Kearfott Kawneer casement windows of large size have been substituted for the unitype windows employed in these spaces on the *California*. These casement windows are of an all-bronze construction and give a spacious airy appearance to these two large rooms.

The *Virginia* has a length overall of 613 feet, a length between perpendiculars of 588 feet 9 inches, a beam of 80 feet, a draft of 32 feet 3 inches, and a displacement of 34,000 tons.

Material Control and Distribution

The first of a series of articles on the "Material Control and Distribution System of the Newport News Shipbuilding & Dry Dock Company" by William B. Ferguson, production manager, and William E. Blewett, Jr., assistant superintendent, of the Newport News yard, will be published in our January issue. The first article will describe the method of scheduling, the paper work involved and the operation of the system. The second article will cover the material distribution system, giving details of the physical work of handling materials, and explaining the requisitioning of materials. The third article will tell what has been accomplished at the Newport News yard by the use of this system, giving a comparison of the cost of building ships before and after the installation of the system. William B. Ferguson, who devised this system, was honor man in 1900 at the United States Naval Academy. After completing a post graduate course in naval architecture and marine engineering in 1904, he served as a naval constructor in the United States Navy until July 1915, when he resigned to become production manager of the Remington Arms Company at Bridgeport, Conn. In June 1917, he became assistant to the president of the American International Shipbuilding Corporation, in charge of production engineering at the Hog Island yard. Since 1924, Mr. Ferguson has been production manager of the Newport News yard.



William B. Ferguson

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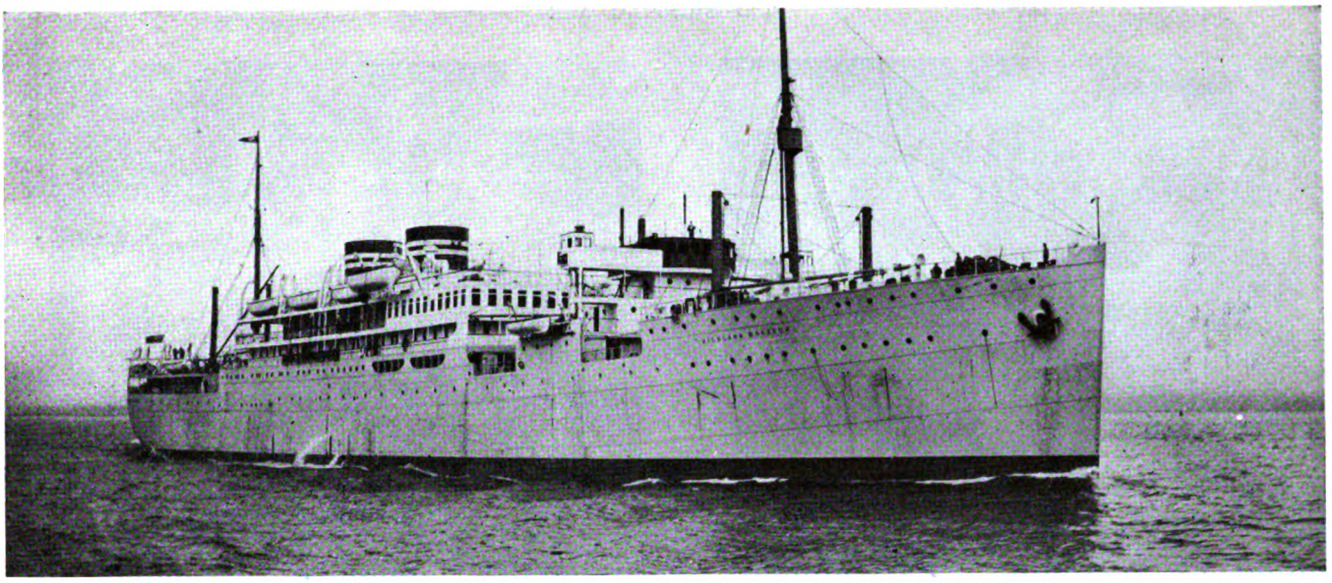


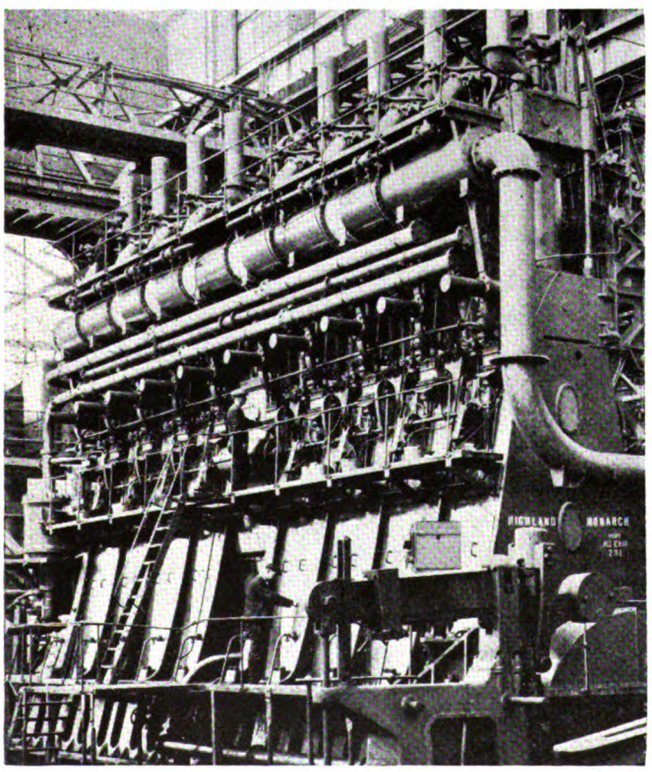
The Nelson liner Highland Monarch

Passenger Liner Highland Monarch

One of five new Nelson Line motorships for South American service—Refrigerating machinery of new type

By Our Special London Correspondent

TO meet the keen competition for South-American trade, which has developed in recent years, the Nelson Line, which is associated with the Royal Mail Steam Packet Company and is, therefore, presumably, more or less controlled by Lord Kylsant, some time ago inaugurated a construction program, consisting of five motorships. These vessels, the first of which, the *Highland Monarch*, has just been completed, are of somewhat larger size and about the same speed, namely 15 knots, as earlier vessels built for this service. All the liners will go into commission by the middle of 1929.



One of the 4000-brake horsepower, double-acting, four-stroke Diesel engines

Characteristics of the Highland Monarch

The *Highland Monarch*, like all recent passenger liners constructed for the companies of which Lord Kylsant is in control, is distinctive in the matter of funnels. It has two, and these are low, of elliptical section, giving the ship a distinctive appearance somewhat on the lines of the *Alcantara* and *Asturias*, but on a smaller scale. She was built by Harland & Wolff and the engines are similar to those in the Royal Mail liners, but smaller. Although their designed output is now stated to be a total of 8000 brake horsepower, the output could be increased, the speed being raised to a certain extent should this be desirable in the future, for they operate at only 95 revolutions per minute, whereas in the *Asturias* the speed is 110 revolutions per minute.

The main details of the *Highland Monarch* as well as those of the four remaining ships, the *Highland Chieftain*, the *Highland Brigade* and two which are still unnamed, are as follows:

Length between perpendiculars	520 feet
Molded beam	69 feet
Depth to upper deck	35 feet 9 inches
Machinery power	8000 brake horsepower
Gross tonnage	14137
Deadweight capacity (cargo)	5000 tons
Service speed	16 knots
Number of passengers	
First class	135
Intermediate class	66

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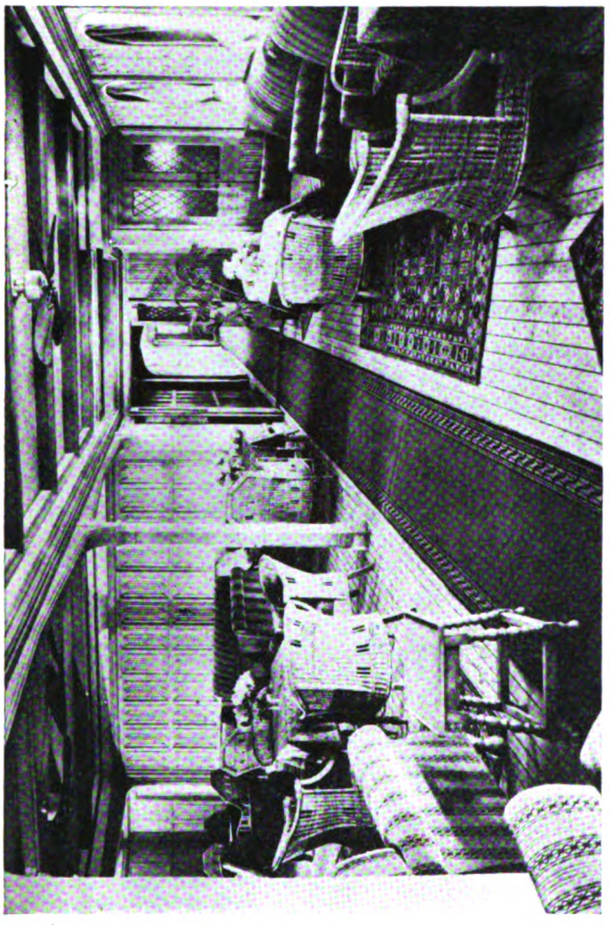
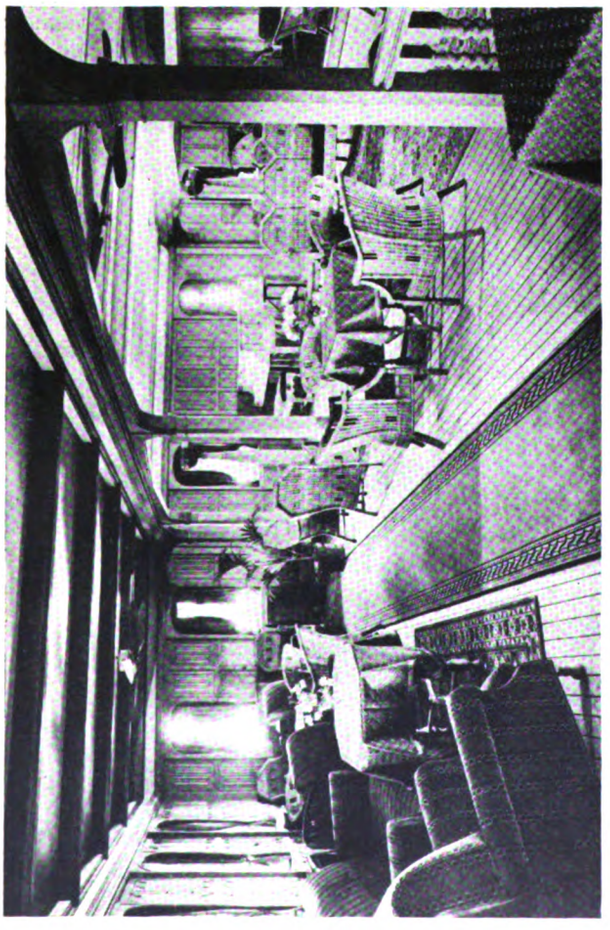
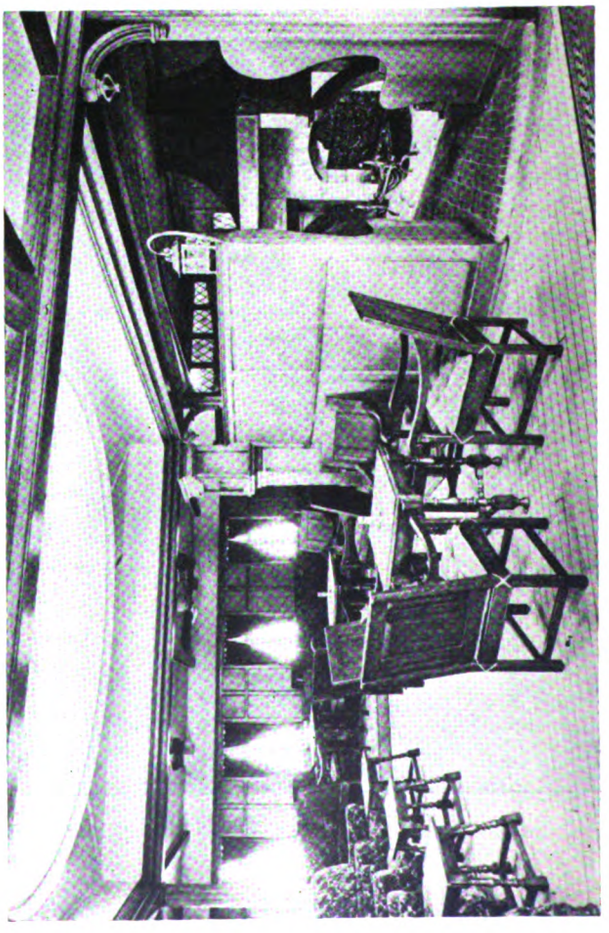


Lounge

Dining room



Recreation room



Smoking room

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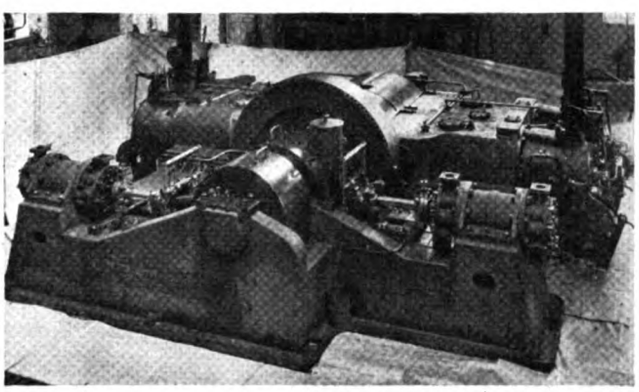
Novelties in Refrigeration

The most important features of the *Highland Monarch* are the exceptionally large refrigerating space available, and the adoption of a new method of driving the refrigerating machinery. In all, about 5000 tons of refrigerated cargo can be carried, mostly chilled meat, fruit and provisions. The total refrigerated cargo space represents 500,000 cubic feet and forms the bulk of the cargo space, since the amount not insulated is approximately 60,000 cubic feet.

The refrigerating machinery will excite universal interest among marine engineers, for it is quite unlike any previous installation. The problem confronting the owners and engineers was novel. In considering the problem, the owners came to the conlusion that it would be advantageous if the refrigerating machinery were entirely independent of the rest of the machinery on the ship. The conditions could not be met, by the



Horizontal oil-engine driven refrigerating plant

installation of either a steam-driven refrigerating plant, which would be uneconomical, or electrically-operated machinery, which would be dependent on the engine-room generators. It was, therefore, decided to fit compressors coupled direct to oil engines so that the advantages both of economy and independence would be achieved. By utilizing a horizontal design of engine, the plant could be built of very low height and, therefore, easily fitted in 'tween decks.

There are two compressors and each is driven by a four-cylinder oil engine, constructed by the Premier Gas Engine Company. The engines are of the four-cycle, single-acting type with cylinders arranged *vis-à-vis* in pairs.

Each engine is designed to develop 308 brake horsepower at 179 revolutions per minute. The cylinders are 16½ inches in diameter with a piston stroke of 24 inches. It is stated that the fuel consumption is under 0.4 pound per brake horsepower hour.

Exhaust Boiler

Further attempts have been made in the design of this ship to render the plant unusually economical, and for the first time, where four-cycle, double-acting machinery has been installed in a passenger ship, advantage has been taken of the heat in the exhaust gases to raise steam for various purposes on the ship. The exhaust from one of the engines is taken through a Clarkson thimble-tube boiler, which also acts to some extent as a silencer. It is able to generate nearly 5000 pounds of steam per hour, although it is quite small in size, being only 6 feet in diameter with a height of 12 feet 6 inches. The steam pressure is about 70 pounds per square inch. This boiler can be oil-fired when in port, and the steam is sufficient for all purposes in the galleys, besides doing other work on the ship.

Harland-Burmeister & Wain Engines

The propelling engines are of the standard Harland-Burmeister & Wain, double-acting, four-stroke type and introduce no novel features as compared with previous motors of this class. They are each designed to develop 4000 brake horsepower at 95 revolutions per minute in eight cylinders, 680 millimeters bore with a piston stroke of 1600 millimeters. This piston stroke is exceptionally long, being, in fact, greater than that utilized in any previous four-stroke, double-acting engine. Lubricating oil is, as usual, employed for cooling the pistons, the cylinder oil being utilized for the bearings. In order to safeguard this important supply, there are no fewer than four vertical four-stage, electrically-driven pumps, having in all a capacity of 640 tons per hour.

A separate type of strainer known as the Auto Klean is used, in addition to which centrifugal separators of the Sharples type are provided; two are for purifying the lubricating oil and three for the fuel oil. For enabling the propelling engines to operate at very low speeds, arrangements are made for the control of the litt of the fuel valves, both at the top and at the bottom of the cylinders, this being a system which has not universally been adopted in the past, especially in engines operating at a higher speed.

Everything on the ship is electrically-operated, except the refrigerating plant and four 300-brake-horsepower, six-cylinder, four-cycle engines are installed in the engine room, each coupled to a 200-kilowatt generator running at 200 revolutions per minute. Two 50-kilowatt emergency sets complete the generating equipment.

Quick handling of the cargo is accomplished by 18 electrically-driven winches, one of 5 tons capacity and the remainder of 3 tons. There are two 7-ton warping winches for docking. The anchor windlass is driven by an 85-brake-horsepower motor, and the steering gear is of the four-ram type, the pumps being driven by 60-horsepower motors. Curiously enough, no motor lifeboats are carried on this ship, as, according to revised Board of Trade regulations, it is permissible to replace them by manually-propelled craft.

There are nine watertight bulkheads in the ship, and the double bottom extends the whole length, being arranged for the carriage of water ballast, fresh water and oil fuel. At a speed of 15 knots it is probable that the daily fuel consumption will work out at approximately 35 tons.

Accommodations

As there is a relatively small number of passengers carried, the accommodations are spacious, the first class staterooms being mainly large two-berth cabins. The public rooms include the dining saloon, paneled in dark oak, with oak beams and dark ceilings, with Tudor arches running fore and aft. The tables are arranged in bays, in the old English style. The smoking room is in light oak with a ceiling of ivory white and oak beams and there is a large glazed dome in the center which has concealed lights.

Aft of the smoking room is a veranda as well as a lounge and recreation room, paneled in gray oak and provided at the forward end with a stage. The intermediate passengers are accommodated in two and four-berth staterooms and their public rooms include a dining saloon, smoking room and ladies' lounge.

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Use of Electricity on Board Ship

Notes for the study of electricity and its application in connection with the operation of a ship

By David Gaehr*

EVERY orthodox treatise on electricity is supposed to start with the time-worn preamble that "no one knows what electricity is," but we have learned much of the laws by which it is governed, and, with the aid of that knowledge, are able to obtain very beneficial results. Suffice it to remind the reader that electricity is one form of energy, and, as such, it can be transformed into other forms of energy, bearing in mind that such transformation is inevitably attended by transformation losses.

Almost everyone is familiar with the fact that there are two principal kinds of electricity, usually referred to as (1) static electricity, often called frictional electricity, such as we find in X-ray machines, radio equipment, lightning phenomena, etc., and (2) current electricity, generated either by batteries, or by dynamos. With static electricity the operating engineer need not concern himself very much, but he ought to understand the generation and characteristics of current electricity, for upon current from dry cells, and sometimes from storage batteries, alarm bells, telephones, etc., depend, while electric lighting systems, motors, etc., receive their supply of current from dynamos.

In the vernacular, we hear much of "juice," as designating electricity, and this gives the impression that it is a liquid. Indeed, its behavior is generally explained by analogies to the characteristics of water under pressure, with which every one is readily made familiar. However, the comparison is not entirely consistent and, in some ways, misleading; for electricity is an invisible force and only through its manifestations produces visible results. Nor does it go to waste and drain the system, when the "line" is broken (unless grounded), nor does it freeze, or boil, etc. There is another striking difference between a water system and an electric circuit, namely, a dynamo supplies current only as it is used, within the limits of its capacity, whereas a pump, working at constant speed, delivers a definite quantity of water, so that fluctuations in the demand, below its regular capacity, have to be taken care of through relief-valve wastage, or stored in an accumulator, or storage tank. In electric circuits, storage batteries are sometimes put in the line to serve as an accumulator, for the purpose of storing up energy when not demanded, in order to be able to draw on such reserve when the peak load comes on, which is usually in excess of the rated capacity of the system.

Enlarging on this familiar picture (imperfect though it be) of a water system, with its pressure pump, pipe line and outlets, for the purpose of bringing home some of the important rudimentary principles of an electric current, we liken the piping system of the former to the wiring system of the latter, the pump to the dynamo, the spigots and places where water is drawn (to be used or to do work) to electric lights, motors and heating appliances.

Obviously water must be confined to be subject to control and for this purpose, pipes, hose, etc., of strength commensurate with the pressure to which they are subjected are used, the kind of material being of secondary importance unless acidity in the water and similar deteriorating influences must be guarded against. Electricity, on the other hand, will flow in most metals (and in many liquids) though not with equal facility, some materials offering decidedly more resistance to the passage of electric current than do others. Those offering comparatively little resistance, and called conductors, are silver (best), copper (next), gold, aluminum, zinc, platinum, iron, nickel, tin, lead, antimony, mercury, carbon, down to bismuth (poorest). Water, either clear or mixed with salts or acids, is also a conductor. Substances which do not permit electrical current to flow through them are called insulators, or dielectric materials. These include rubber, mica, insulating varnishes, fiber, porcelain, asbestos, wood, slate, stone, glass, silk, etc.

This is the first of a series of articles written especially for the benefit of the men in the engine room who are responsible for the operation and upkeep of electrical machinery and equipment on board ship. The following articles will cover the generation of electrical current in dry batteries and storage batteries; magnetism; the generation of current in dynamos or generators; characteristics of various circuits, including measuring instruments and distributing panels; the cardinal points in special applications of electricity on board ship, such as electrical whistle control, rudder indicator, gyro-compasses, heating devices and the like; electrically-driven ships on the Great Lakes and a discussion of the future possibilities with electric drive. David Gaehr, author of these articles, has been in charge of the Lake Carriers' Association School of Marine Engineering at Cleveland, O., since 1912 and holds a chief engineer's license for ocean-going vessels of unlimited tonnage. Mr. Gaehr is a graduate of Cornell University and has had a wide experience with various industrial and manufacturing concerns as apprentice, draftsman, inspector, assistant to manager and superintendent as well as thirteen years' experience as a consulting, designing and contracting engineer.

David Gaehr

* Instructor, Lake Carriers' Association School of Marine Engineering, Cleveland, O.

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It should be noted that electricity always follows the path of least resistance, the unit of electrical resistance being the ohm. This resistance depends not only on the characteristics of the material used in the circuit, but also on their cross-sectional area, the resistance increasing as the temperature increases.

However, just as water will not flow unless actuated by a force, so electricity will not flow, unless there is a difference in pressure, often called potential or electromotive force (e.m.f.), the unit of which is the volt. The unit of flow is the ampere and the unit of power is the watt. Obviously, then, electricity under control demands a *closed* path (circuit) generally metallic, unless the pressure is so great between two points separated by an air gap as to cause it to jump across, or unless, for instance, a human body or a part of a body may suddenly offer a shorter and easier path to a point of lower potential than does the rest of the metallic circuit.

These simple facts an operating man must know and always bear in mind. It will be interesting, in his further studies, to learn how these various units are specifically defined and standardized. He should also understand and remember their relation, as expressed in Ohm's law, namely:

The current (in amperes) is equal to the pressure (in volts) divided by the resistance (in ohms), commonly represented by the formula

$$I = \frac{E}{R}$$

where,

I is the abbreviation for current
E is the abbreviation for pressure
R is the abbreviation for resistance

Knowing any two of these quantities, the third can readily be found by substituting the numerical values of the terms known in the above expression.

Or, they can easily be transposed for solving direct:

$$E = R \times I \text{ and } R = \frac{E}{I}$$

Another important thing to remember is that volts × amperes = watts and 1000 watts = 1 kilowatt and 746 watts = one horsepower.

Practically every concern making conductor wire issues a booklet containing a table of "safe current carrying capacity" of the various sizes of wire. Before making an installation this matter must be carefully investigated so that wires will not be overloaded, for that results in undue heating which may cause the insulating coverings to break down and permit a short circuit, if the damaged portion comes in contact with another conductor of lower potential, though protective devices like fuses and circuit breakers are usually installed to avoid this.

Direction of Flow

Furthermore, in many installations it is imperative to know the direction in which the current is flowing.

In general, that terminal (or pole) is considered positive (+) from which the current flows into the external circuit, and, hence, the terminal (or pole) to which the current returns from the external circuit is designated as negative (—). To determine the polarity, i.e. to ascertain whether a terminal is positive or negative, the ends of wires connected with the two terminals (separately) are immersed in a glass of water containing about a teaspoonful of salt, without allowing the ends of the wires to touch. Fine bubbles of colorless gas will be given off at the end of the wire connected with the negative terminal. Or, when these wires are stuck into a peeled potato, about ½-inch apart, a blue ring will form around the positive wire. Or, if a compass be placed over a wire carrying current, the north end of the needle, on approaching the wire, will be deflected toward the right, when the observer is looking in the direction of the flow of current, or, conversely if the needle is deflected to the left, when approaching the wire from underneath.

In many cases, as lighting, etc., it does not matter in what direction the current flows if this is supplied by just one battery or one generator, but trouble begins, when trying to hook up several batteries or generators without having this matter of polarity clearly understood. In the case of motors driven from such battery or generator, a reversal of the motor occurs, of course, if, for any reason the direction of the current flow is changed and that may cause trouble depending on what the motor is driving.

These elementary facts apply both to battery current and to dynamo current, and should be firmly fixed in an engineer's mind.

The National Carbon Company of New York has issued some excellent booklets, such as "Analogies between Battery Current and Water Flow" and "Dry Battery Handy Book. A Primer of Electricity," which they have distributed free of charge, going into further detail to explain the above relations and showing how to connect up batteries to obtain the desired voltage and current strength.

Similarly, The Electric Storage Battery Company of Philadelphia issues a very useful book of instructions, called "Manual for Exide Batteries," which is worth writing for by those in charge of storage batteries.

Danger to Human Body

Ordinarily such current as is used aboard ship does not have fatal results for one coming in contact with it, for the lighting circuits are usually designed for 110 volts and, besides the surprise occasioned by the shock received, one of sound heart and constitution should scarcely experience any discomfort worth mentioning.

The real danger is not so much the high voltage as the current which a high voltage can send through the body, the resistance of which is around 10,000 ohms, if hands and feet are dry. Standing on a steel deck and touching a "live" bare wire would cause current to make a "ground" through the body, if there were an unbroken path.

Applying the relation expressed in Ohm's law, we see that, if a body has the resistance given and comes in contact with a wire carrying 1000 volts, the current passing through the body is only 0.1 ampere. This, however, usually causes death, because of the heating effect on the nervous system, since a fever of 105 degrees Fahrenheit is usually fatal.

It is seen from this that for conditions of the ordinary current aboard ship, only about 0.01 ampere would pass through a body "grounding" it. Two thousand volts are usually dangerous, especially in cases of good contact through sweaty hands, although some men can stand 500 volts without being knocked out.

However that be, other injuries, like falling, bruising, etc., may result from the sudden shock, or things may be dropped, or wrong movements made. Therefore, it behooves one to be careful, to use rubber mats around generators and switchboards and to think and endeavor to "foresee trouble and avert it".

(*To be continued*)

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Forced-Blast, Chain-Grate Stoker Tests of Marine Watertube Boiler*

By T. B. Stillman

THE boiler used for these experiments was of the usual Babcock & Wilcox marine type, built in 1910, and was originally fitted for hand firing. The tubes were 8 feet long between headers, the boiler being sixteen headers wide. Each header had one 4-inch tube in the furnace or bottom row, and, above that, nine groups of four 2-inch tubes. The total heating surface of the boiler was 2706 square feet, the furnace volume 167 cubic feet, and the surface of the forced-blast, chain-grate stoker 58 square feet. The boiler was fitted with a small Babcock & Wilcox superheater located at the top of the first and second passes of the boiler. No air heater was used with the boiler, air taken directly from the fire room being used for combustion purposes. Diamond soot blowers were fitted to both the boiler and superheater.

At the last annual meeting of the Society of Naval Architects and Marine Engineers a paper was presented by the writer, entitled "Pulverized Coal Tests of a Marine Watertube Boiler." The present paper is devoted to a description of tests run with a forced-blast, chain-grate stoker installed under the same boiler at the Bayonne Works of the Babcock & Wilcox Company. The object of conducting the tests reported in both of these papers was the same, namely, to develop methods for satisfactorily and efficiently utilizing coal as a fuel under marine watertube boilers, without requiring the heavy manual labor involved in hand firing.

Fig. 1 shows longitudinal and front view sections of the furnace with the forced-blast, chain-grate stoker as installed for the tests. "C" tile were used over the bottom row 4-inch tubes up to the first pass opening from the furnace, to supply the refractory arch so desirable for combustion purposes over chain-grate stokers. Air was admitted over the fire, entering the furnace in a direction parallel to the surface of the grate, through a multiplicity of small holes connected with the air pipe shown, which was recessed in the brickwork immediately alongside of the lower boiler cross-box. The side water-boxes of the furnace, which had been installed when the boiler was originally built, were removed, and brick walls, suitably insulated, were built in each side wall above the top of the stoker. The rear wall, which was also of brick, was supported on a square cross-box, which was in turn connected with the water circulation of the boiler.

The forced-blast, chain-grate stoker was designed by Babcock & Wilcox Company engineers and built in the Barberton Works of that company especially for this marine application. Its essential features are similar to the larger stokers of the same type manufactured by that company for stationary service. As may be noted, four blast compartments were used, an individual damper control being provided between each compartment and the forced-blast duct leading from the fan. In this way suitable control of the blast in each portion of the stoker was obtained at all times, depending upon the rating and type of coal being used. The driving links of this stoker were made of steel forgings, the intermediate links between the driving links being iron castings. The stoker was fitted with a 1½-horsepower motor, which, through a suitable reduction speed drive, drove the chain grate at the rate desired. The motor was of the variable-speed type, suitable control of the speed of the grate being obtained in this manner.

When the stoker was first installed the ashes or refuse were allowed to discharge over the rear of the same into a square compartment fitted with suitable doors through which they could be removed by hand and weighed at intervals. As this would not be a convenient procedure to follow in all marine installations, a compact ash conveyor was designed and installed for us by the Allen-Sherman-Hoff Company of Philadelphia, this conveyor being shown in section in Fig. 1 under the rear of the stoker. With this conveyor the ashes were allowed to store in the space above it until it was partly filled, when the motor driving the conveyor would be started and in a few minutes the ash receiving space would be entirely cleared, the discharge of the conveyor being on the side of the boiler at the rear. On the average this conveyor would be used five minutes out of every hour, although at the lower rates of operation several hours could elapse before it was necessary to remove the ashes. Where greater headroom is available a larger space could be built above the ash conveyor and the time interval between successive uses of the latter greatly extended. Although about 3 horsepower was required to operate this ash conveyor during the time it was in use, when this was expressed in horsepower required per hour, the average load due to this conveyor was only a fraction of a horsepower (see Table 1).

As it was necessary for test purposes to weigh the ashes as they were discharged, no further steps were taken to dispose of them automatically beyond the discharge point of the ash conveyor, but in an actual installation on shipboard means could be provided to eject these overboard automatically as rapidly as they were discharged from the conveyor at the rear of the stoker. In this connection it should be said that the conveyor in question not only moves the ashes in a horizontal manner to the aisle between the boilers, but also crushes them to some extent, so that they are in a relatively fine condition for ready disposal by any of the automatic ash ejectors at present on the market.

A 6-foot diameter fan, driven by a 90-horsepower mo-

[* Paper read at the thirty-sixth general meeting of the Society of Naval Architects and Marine Engineers, held in New York, November 15 and 16, 1928.]

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tor, was used to provide the blast under the stoker but as these units were so large in proportion to the actual power requirements, no effort was made to measure the electrical input to them. Approximate figures of the power that would be required in a properly designed installation are from 2.5 to 5.5 horsepower over the range covered in the subject tests.

Fig. 2 shows the stoker in operation and clearly indicates some of the more essential features. The handwheel at the left is used for raising and lowering the level of the stoker gate. The coal chute for discharging the coal from the weighing platform to the stoker hopper is shown in the upper left-hand corner, together with the curved pan located at the discharge of the chute for assisting in the distribution of the coal to the hopper. The 1½-horsepower electric motor with its speed-reduction drive is clearly shown on the right of the stoker, and farther along the side wall of the stoker are shown the four handles for controlling the blast to the individual compartments. The curved pipe above these handles was the one used to bring the air from

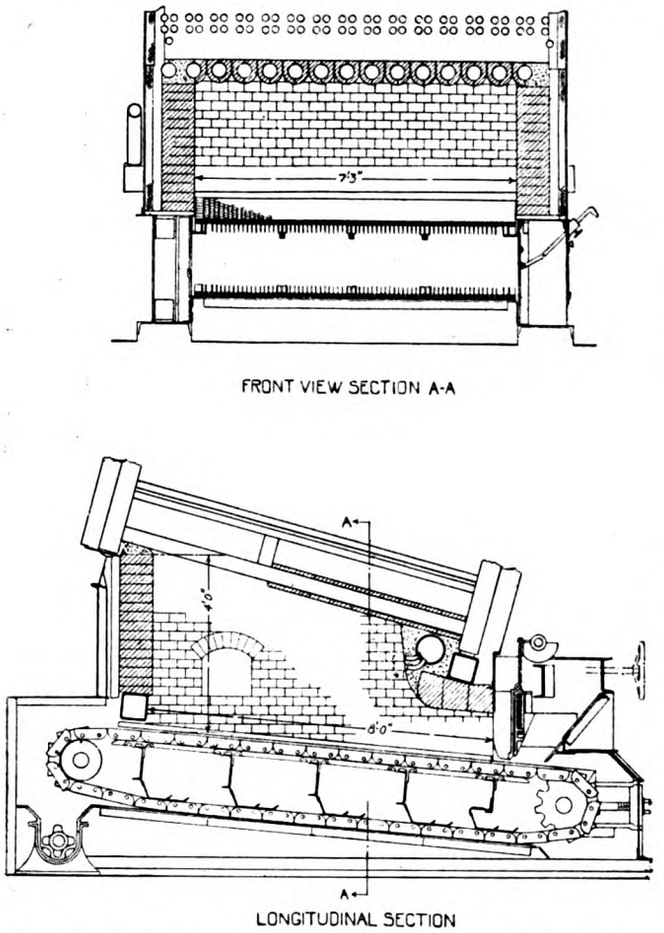

Fig. 1.—Front view and longitudinal sections of chain-grate stoker installation

the blast duct to the pipe located in the brickwork over the fire.

The boiler was operated with an open fire room at all times, and, if drafts in excess of that given by the stack operating natural draft were required, a steam jet was turned on which gave a maximum available draft of 1.35 inches at the top of the third pass of the boiler. This draft available from the steam jet was the limiting factor in the rate which it was possible to obtain with this stoker. It may be noted that, at the higher rates of operation, all of this draft was utilized in moving the gases from the furnace to the uptake.

Description of Tests

With the equipment described above a series of tests was run during July and September, 1928, the complete tabulation of these tests being given in Table 1. Table 2 gives representative proximate and ultimate analyses of the two types of coals used in the tests reported in

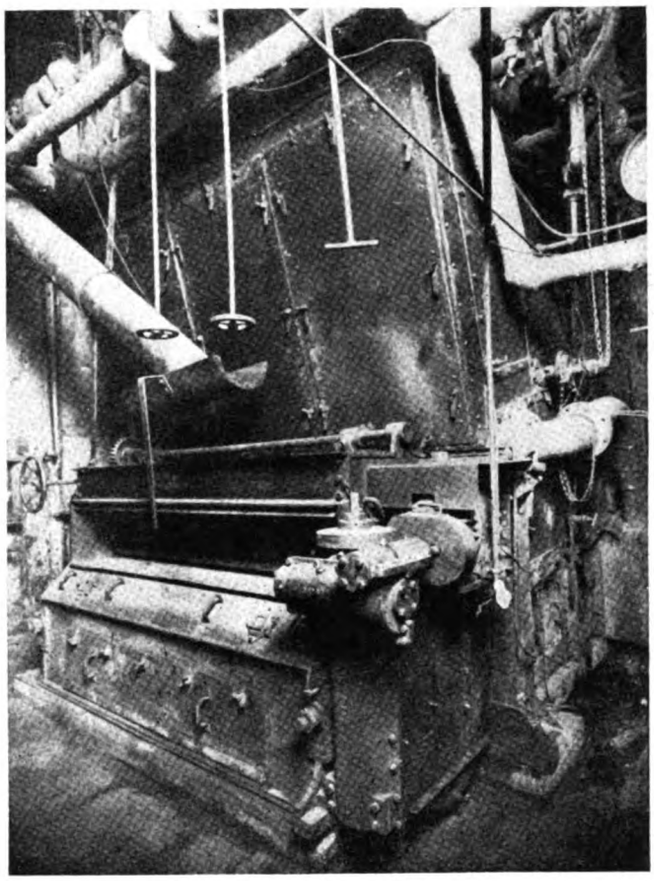

Fig. 2.—General view of the chain-grate stoker installation

Table 1, the first one being the regular Bayonne Power Plant coal (Dundon gas slack) and the second a special shipment of Pocahontas coal secured from the Berwind-White Coal Company for experimental purposes.

Fig. 3 shows graphically the boiler efficiencies and uptake gas temperatures secured during these tests. Fig. 4 is a graphical representation of the heat balances showing distribution of the heat fired in the coal, when the Dundon gas slack was used.

Although, as may be noted by referring to Table 1, the CO_2 was maintained relatively high for all tests, the loss due to unconsumed CO in the products of combustion was negligible, and the quantity of smoke made was never an important factor, even at the highest rates with the high volatile coal. It is well to emphasize at this point that, although the Dundon gas slack coal did give a noticeable trace of smoke (one-half on the Ringelman chart) at the higher rates, the Pocahontas coal never made any smoke whatever during the testing period. It was difficult to tell, when this coal was used, whether the boiler was on the line or not from observing the top of the stack.

No difficulty was experienced at any time, with either of the two coals used, from ash or slag collecting on

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Table 1.—Tests of a Babcock & Wilcox Marine Boiler, Fitted with a Babcock & Wilcox Superheater and a Babcock & Wilcox Forced-Blast, Chain-Grate Stoker

Boiler Heating Surface, 2,706 Sq. Ft.; Furnace Volume, 167 Cu. Ft.; Grate Surface, 58 Sq. Ft.

		7/2	7/5	7/6	9/11	9/12	9/28	9/14	9/18	9/25	9/26	9/27
1	Date of test, 1928											
2	Duration of test (hours)	6	5	6	5	6	6.5	6	6	6.5	6	6
3	Type of coal used			Dundon	Gas Slack					Pocahontas		
4	Speed of stoker (inches per min.)	2.22	3.39	2.27	3.22	2.82	2.25	2.82	2.82	2.82	3.32	2.27
5	Height of gate (inches)	4.0	4.5	4.0	4.5	4.0	4.0	4.0	4.0	4.0	4.5	4.0
	Steam pressure (lbs.—sq. in.):											
6	Drum	196.7	201.4	191.4	191.5	193.2	194.9	196.8	189.6	193.9	198.8	195.2
7	Superheater inlet	195.7	198.8	189.3	187.9	191.0	193.7	195.0	187.8	191.7	196.2	193.6
8	Superheater outlet	194.7	196.6	188.3	186.5	189.5	192.6	193.7	186.4	190.9	194.4	192.3
	Temperatures (°F.):											
9	Furnace				2554	2617	2350	2637	2568	2457	2497	2389
10	Gas uptake	464.8	541.0	462.9	555.9	518.4	467.7	524.2	522.7	495.2	527.3	473.9
11	Feed water	207.3	187.8	200.8	187.3	176.1	187.2	193.4	193.4	180.9	187.5	176.9
12	Superheated steam	445.3	466.7	441.6	462.8	455.1	445.8	461.5	459.9	452.3	464.0	441.8
13	Calorimeter superheater inlet	311.5	311.8	310.8	310.6	310.7	310.8	311.0	310.0	311.0	311.7	310.3
14	Room	108.9	109.6	99.6	96.1	95.9	88.5	96.3	86.9	90.3	101.2	95.4
15	Air entering stoker	94.1	95.6	90.0	111.5	111.5	109.2	113.6	105.2	114.3	134.2	117.3
	Air pressures (in H_2O):											
16	Main duct	2.39	3.52	2.97	3.54	3.50	2.27	2.97	3.25	2.65	3.17	1.99
17	Compartment No. 1	0.057	0.217	0.179	0.179	0.138	0.100	0.128	0.141	0.231	0.369	0.238
18	Compartment No. 2	0.319	0.636	0.289	0.776	0.541	0.459	0.616	0.627	0.736	1.145	0.701
19	Compartment No. 3	0.158	0.386	0.155	0.444	0.304	0.419	0.343	0.316	0.666	0.987	0.627
20	Compartment No. 4	0.086	0.075	0.072	0.012	0.000	0.014	0.000	0.000	0.334	0.497	0.351
21	Air duct over fire	—0.086	—0.075	—0.072	2.139	1.557	0.300	1.782	1.958	0.700	0.419	0.137
	Drafts (in H_2O):											
22	Furnace	0.153	0.203	0.176	0.139	0.147	0.087	0.093	0.131	0.050	0.061	0.052
23	Uptake	0.630	1.349	0.612	1.259	1.036	0.598	1.002	1.001	0.992	1.377	0.730
	Gas analysis (%):											
24	Top 1st Pass CO_2	15.06	14.57	15.10	15.71	15.89	14.22	16.11	15.92	14.13	14.78	13.74
25	Top 1st Pass O_2	3.25	3.23	4.15	2.43	2.76	4.29	2.20	2.90	4.68	4.15	5.24
26	Top 1st Pass CO	0.01	0.69	0.00	0.67	0.13	0.00	0.08	0.07	0.00	0.00	0.00
27	Top 1st Pass N_2	81.68	81.51	80.75	81.19	81.22	81.49	81.61	81.11	81.19	81.07	81.02
28	Top 3rd Pass CO_2	13.07	13.64	13.25	13.28	13.89	13.04	14.40	13.74	12.90	14.61	13.18
29	Top 3rd Pass O_2	6.14	5.36	6.10	5.23	5.35	5.61	4.32	5.15	6.17	4.10	5.99
30	Top 3rd Pass CO	0.00	0.35	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31	Top 3rd Pass N_2	80.79	80.65	80.65	81.16	80.76	81.35	81.28	81.11	80.93	81.29	80.83
32	Quality of smoke	0 to .25	.50	Trace	.50	.25	0 to .25	.25	0 to .25	Trace	0	0
33	Total water evaporated (lbs.)	61245	83109	60353	75808	76305	61064	79954	73591	86114	101608	67908
34	Total wet coal fired (lbs.)	6959	9917	6968	9209	8840	7191	9009	8560	8772	10494	6836
35	Total refuse, dry (lbs.)	1014.9	1205.3	877.0	1165.1	1266.0	1037.0	1004.1	918	760	987	580
36	Moisture in coal (%)	8.58	8.42	7.60	11.15	7.07	7.31	7.32	8.06	4.30	3.21	2.74
37	Quality of steam S.H. inlet (%)	99.90	99.88	99.90	99.90	99.88	99.87	99.87	99.87	99.89	99.90	99.84
38	Calculated saturated steam temperature at S.H. outlet (°F)	385.76	386.52	383.10	382.38	383.60	384.92	385.36	382.34	384.24	385.64	384.80
39	Degrees superheat at S.H. outlet (°F)	59.54	80.18	58.50	80.42	71.50	60.88	76.14	77.56	68.06	78.36	57.00
40	Factor of evaporation	1.0940	1.1255	1.0987	1.1248	1.1318	1.1146	1.1171	1.1170	1.1251	1.1245	1.1229
41	Total water F & A, 212° F. (lbs.)	66965.3	93539.2	66309.8	85268.8	86362.0	68061.9	89316.6	82201.1	96886.9	114258.2	76253.9
42	Water evaporated per hr. actual (lbs.)	10207.5	16621.8	10058.8	15161.6	12717.5	9394.5	13325.7	12265.2	13248.3	16934.7	11318.0
43	Water per hour F & A, 212° F. (lbs.)	11160.9	18707.8	11051.6	17053.8	14393.7	10471.1	14886.1	13700.2	14905.7	19043.0	12709.0
44	Water per hour F & A, 212° F. per sq. ft. of H.S. (lbs.)	4.125	6.913	4.084	6.302	5.320	3.870	5.500	5.060	5.508	7.037	4.697
45	Total dry coal (lbs.)	6361.9	9082.0	6438.4	8182.2	8215.0	6665.3	8349.5	7870.1	8394.8	10157.1	6648.7
46	Wet coal per hour (lbs.)	1159.8	1983.4	1161.3	1841.8	1473.3	1106.3	1501.5	1426.7	1349.5	1749.0	1139.3
47	Dry coal per hour (lbs.)	1060.3	1816.4	1073.1	1636.4	1369.2	1025.4	1391.6	1311.7	1291.5	1692.9	1108.1
48	dry coal burned per cu. ft. of F.V. per hour (lbs.)	6.35	10.88	6.43	9.80	8.20	6.14	8.33	7.85	7.73	10.14	6.64
49	Dry coal burned per sq. ft. of H.S. per hour (lbs.)	0.392	0.671	0.397	0.605	0.506	0.379	0.514	0.485	0.477	0.626	0.409
50	Wet coal burned per sq. ft. of grate surface per hour (lbs.)	20.00	34.20	20.02	32.89	25.40	19.07	26.81	24.59	23.27	30.15	19.64
51	Dry coal burned per sq. ft. of grate surface per hour (lbs.)	18.28	31.32	18.50	28.21	23.61	17.68	23.99	22.62	22.27	29.19	19.11
52	Actual evaporation per lb. dry coal (lbs.)	9.63	9.15	9.37	9.27	9.29	9.16	9.58	9.35	10.26	10.00	10.21
53	Equivalent evaporation per lb. dry coal (lbs.)	10.53	10.30	10.30	10.42	10.51	10.21	10.70	10.44	11.54	11.31	11.47
54	B.t.u. per lb. dry coal	13072	13277	12867	13180	13206	12875	13310	13222	14642	14548	14572
55	B.t.u. liberated per cu. ft. F.V. per hour	82994.1	144413.9	82734.8	129150.8	108289.2	79052.5	110912.2	103845.6	113182.7	147516.7	96758.1
56	Total air supplied per hour (lbs.)	12730.0	21633.3	13381.6	18982.2	16186.7	12858.5	16086.9	15643.3	19750.9	23837.7	16937.3
57	Per cent excess air used for combustion	17.75	15.01	24.17	12.80	14.78	24.91	11.37	15.67	33.91	24.06	32.45
58	Average Horsepower per hour—stoker	....	....	...	0.704	0.706	0.693	0.699	0.709	0.707	0.699	0.708
59	Average Horsepower per hour—ash conveyor	....	....	....	0.247	0.206	0.248	0.184	0.333	0.152	0.295	0.174
60	Average total H.P. per hour—stoker and ash conveyor	....	....	....	0.951	0.912	0.941	0.883	1.042	0.859	0.994	0.882
61	Efficiency—boiler, superheater and furnace (%)	78.17	75.28	77.68	76.72	77.23	76.95	78.01	76.62	76.48	75.44	76.38
	Heat balance (%):											
62	Heat absorbed by boiler	78.17	75.28	77.68	76.72	77.23	76.95	78.01	76.62	76.48	75.44	76.38
63	Loss due to moisture in coal	0.90	0.85	0.77	1.19	0.71	0.75	0.73	0.83	0.38	0.28	0.23
64	Loss due to water from combustion of hydrogen	3.88	3.93	3.94	4.19	4.12	4.17	4.10	4.15	3.39	3.42	3.36
65	Loss due to dry chimney gases	9.16	10.12	9.07	11.24	10.03	9.78	9.84	10.63	10.80	10.13	9.92
66	Loss due to incomplete combustion of carbon	0.00	1.36	0.00	1.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00
67	Loss due to unburned carbon in refuse	2.61	1.33	2.33	2.74	3.34	3.81	2.72	2.06	2.71	3.43	3.39
68	Radiation and unaccounted for	5.28	7.13	6.21	2.57	4.57	4.54	4.60	5.71	6.24	7.30	6.72
69	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
70	Refuse—per cent of dry fuel	15.95	13.27	13.62	14.25	15.41	15.60	12.03	11.06	8.63	9.72	8.72
	Refuse anaylsis:											
71	Combustible	14.68	15.65	15.09	17.35	21.07	21.57	20.58	16.25	34.18	35.14	38.78
72	Ash	85.32	84.35	84.91	82.65	78.93	78.43	79.42	83.75	65.82	64.86	61.22

the furnace row of boiler tubes, the furnace walls, or with clinkering on the grate, and at no time was it necessary to use slice bars or similar tools in the furnace.

The siftings which collected in the front compartment were appreciably higher in carbon content than the refuse at the rear of the stoker. This was due to the small quantities of fine coal that sifted through the stoker and increased the carbon content of the deposit in the front compartment. Because of this relatively high carbon content in the front compartment siftings, it is entirely practicable to take these siftings from the compartment at intervals and discharge them in the coal hopper of the stoker, provided care is taken to scatter them fairly well through the coal in the hopper. If

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FORCED-BLAST, CHAIN-GRATE STOKER TESTS

TABLE 2.—COAL ANALYSIS

ULTIMATE ANALYSIS OF DRY COAL	Dundon gas slack Dundon, W. Va.	Pocahontas Screened coal West Virginia
Carbon	74.47	85.97
Hydrogen	4.90	4.49
Nitrogen	1.42	1.24
Sulphur	.66	.68
Ash	11.94	5.74
Oxygen	6.61	1.88
PROXIMATE ANALYSIS		
Moisture	7.36	2.41
Volatile matter	33.85	18.40
Fixed carbon	54.21	75.86
Ash	11.94	5.74
Sulphur	.66	.68
Fusing point of ash (°F.)*	2600	2410

* Defined as softening temperature in A. S. T. M. Specification D-22-24.

they are not scattered, the fire is liable to become spotty. In the case of the Pocahontas coal tests, all of these siftings were discharged through the coal hopper. In the case of the Dundon gas slack coal they were not, although equally satisfactory tests have been run when this was done.

Comparative efficiencies obtained running both ways showed no appreciable difference in the boiler efficiencies secured, whether the siftings from the front compartment were discharged in the coal hopper or whether they were weighed directly after removal, sampled, and thrown away. In the case of test work such as we were running at Bayonne, it was more convenient to remove them, sample them, weigh them, and then throw them away, than it was to put them back in the hopper, but on the average ship it would undoubtedly be more convenient to throw them back in the hopper rather than carry them to the rear of the boiler and eject them with the other ashes or refuse.

As the coking type of coal, represented by the Pocahontas which we used, is not usually regarded as a desirable coal for burning on chain-grate stokers because of excessive ashpit losses, we were very much interested to find that, by suitable regulation of the blast in the various compartments of the stoker, we were

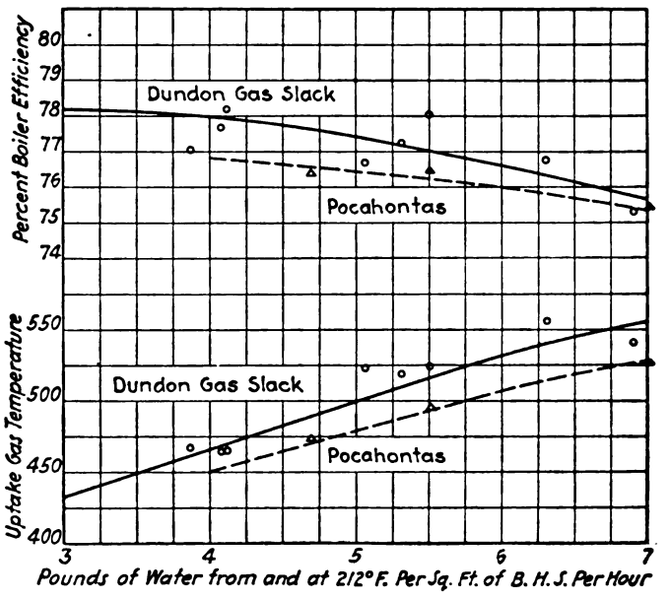

Fig. 3.—Curves showing boiler efficiencies and uptake temperatures

able to handle this with entirely satisfactory results. The results in question, it may be noted, were on the average within ½ percent of those obtained with the Dundon gas slack coal, which is a relatively ideal chain-grate fuel. Referring to the air pressures given in Table 1, when burning the Dundon gas slack coal, no pressure was used in the last or fourth compartment of the stoker; whereas, with the Pocahontas coal, the use of blast in this compartment was found desirable, to burn up the lumps of coke remaining on the grate passing over this compartment.

Efficiency

The boiler efficiencies, shown in Table 1, compare favorably with what is regarded as good stationary practice, where no air heaters or economizers are em-

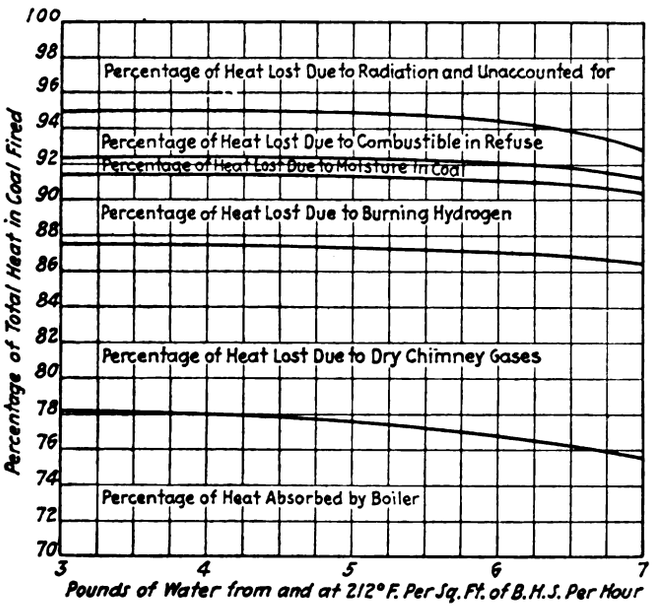

Fig. 4.—Curves showing heat balance

ployed. From the point of view of British thermal units released per cubic foot of furnace volume, the results secured were outstanding, and were approximately as high as any of which the writer has knowledge, where stokers were employed under watertube boilers. Rates as high as 147,000 B.t.u. per cubic foot were secured with boiler efficiencies in excess of 75 percent.

The boiler efficiencies secured with the forced-blast, chain-grate stoker on the boiler averaged between 2 and 3 percent less than the efficiencies secured on the same boiler with the pulverized coal equipment. From the point of view of ship operation, however, the overall efficiencies of the two installations are the ones which should be compared. On this basis, in the average ship, the stoker will be at least equal to, and probably more efficient than, the pulverized coal. In any case, the difference in the overall efficiencies will not be very great provided both installations are efficiently designed and properly installed. Compared to the average hand-fired installation, the overall efficiency of a forced-blast, chain-grate stoker-equipped ship will be at least 10 percent better, realizing a direct saving of 10 percent in the annual coal consumption.

Flexibility for Maneuvering

The maneuvering characteristics of a forced-blast, chain-grate stoker may be likened in every respect to that of a hand-fired installation. The bed of coal is always there ready to start up at a moment's notice, when the damper is opened and the air pressure applied to the stoker. In the same way, when it is desired to check the fire, this may be done promptly by shutting off the draft and pressures, and stopping the forward

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movement of the stoker. In extreme cases the side door of the furnace may be opened, still further checking the fire in a manner similar to that employed with hand-fired installations.

Size of Coal to be Used

The size of the coal supplied to the stoker is of importance from an efficiency point of view. The Dundon gas slack coal used in the tests reported in this paper was ¾-inch screened slack, an excellent size for use on this stoker. Sizes up to 1¼-inch screened slack may be used with satisfactory results. If, in the ship's regular run, coal of this size or smaller is not assured at the pier, it will be desirable to install a crusher on the ship. This may be located so as to crush the coal as it comes into the bunkers, or, if that is not practical, crush it just before it is elevated to the stoker hopper.

Conclusions

1. With a properly designed and installed forced-blast, chain-grate stoker, a wide variety of coals may be burned efficiently in the relatively small furnace volumes normally available under marine watertube boilers.

2. The power required to operate the stoker will average less than 1 horsepower per boiler, a trifling increase in the auxiliary load of the ship.

3. Approximately 10 percent saving in the fuel consumption of the ship may be expected from the use of these stokers, compared to average hand-fired practice.

4. In maneuvering a ship, the flexibility of a forced-blast, chain-grate stoker installation is the same as that to be expected from hand firing.

5. The disposal of the ashes in a forced-blast, chain-grate installation is a relatively simple matter and, by the use of suitable equipment, may be accomplished with no manual labor.

6. Taking account of the reduction in personnel due to the use of stokers, as well as the increase in boiler efficiency, there results an increased "overall efficiency" of the ship which represents an appreciable saving in the cost of ship operation as compared with hand firing. The percentage of this saving increases with the number of boilers, due to the greater reduction in fire-room personnel. Even where there is no great reduction in personnel, the relatively light labor involved in operating stokers will be an important factor in inducing good men to remain with a ship so equipped.

Pulverized Fuel Developments*

Service results of pulverized coal installation on S. S. Mercer—Other installations—Experimental work

By C. J. Jefferson,† Commander J. S. Evans, U.S.N., and Commander J. Broshek, U.S.N.

AT the meeting of the Society of Naval Architects and Marine Engineers held a year ago, papers were presented in which were given the data of two series of tests on marine boilers, using pulverized fuel. The one series, reported by Mr. Stillman, covered the results obtained with a Babcock and Wilcox watertube marine-type boiler, while the report of the other series, which was presented by the authors of this paper, gave the results obtained on a standard three-furnace separate-combustion chamber Scotch marine boiler.

Since that time considerable further development work has been carried on, and it is the purpose of this paper to enumerate the various phases of the problem which have arisen under actual sea-going conditions and the method of attack that has been employed; also to record the further test-plant work that has been carried on during the past year.

Mercer Installation

The pulverizers and burners installed on the S. S. *Mercer* are practically identical with the equipment described in the report of the Scotch boiler tests. The crushers are standard equipment, and the conveyors are also standard equipment with the exception of guard rails and rollers to maintain alinement when the vessel is rolling and pitching.

The installation of the pulverized-fuel plant and coal bunkers were the only changes made to the vessel. Otherwise, her equipment today is just what it was when operated as an oil burner.

It was desired in making the installation on the S. S. *Mercer* to have absolute reliability and such flexibility of arrangement as would take care of any emergency arising from break-down of equipment. To meet these requirements the original installation permitted the feeding of any one, two or all three of the boilers with either pulverizer; also the operation in parallel of the two pulverizers at reduced capacity. Actual operation of this set-up, however, developed a number of difficulties, as the complexity of piping produced an enormous friction load which had to be overcome by the primary-air fan. Moreover, it was found most difficult to synchronize the two primary-air fans of the mills so that they would operate in parallel rather than buck each other.

With this set-up any two of the boilers could be comfortably handled by either mill, but attempts to operate the third boiler were unsuccessful, as the primary-air fan did not have sufficient capacity at the required discharge pressure to maintain the velocities necessary for keeping the coal in suspension, and the result invariably was plugged burner pipes.

During the trials conducted with this arrangement, it was noted that any two of the boilers could supply all the steam required to operate the vessel at her rated speed. Therefore, as it was desired to expedite the commissioning of the vessel, it was decided, rather than install new primary-air fans of sufficient capacity, which

* Abstract of a paper presented at the thirty-sixth general meeting of the Society of Naval Architects and Marine Engineers, held in New York city, November 15 and 16.

† Head of the Fuel Conservation Section, United States Shipping Board.

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would not only involve a delay, but would also mean a continual excessive power consumption by the pulverized-fuel equipment, to rearrange the piping.

In this arrangement the port mill was connected direct through a single distributor to the port boiler and likewise the starboard mill to the starboard boiler, the center boiler being dead. It was with this arrangement that the vessel steamed away from the Maryland Dry Dock Company on the afternoon of November 4, 1927, on the first off-shore cruise of a sea-going vessel using pulverized coal as a fuel. This same arrangement was continued in service for the first three transatlantic voyages

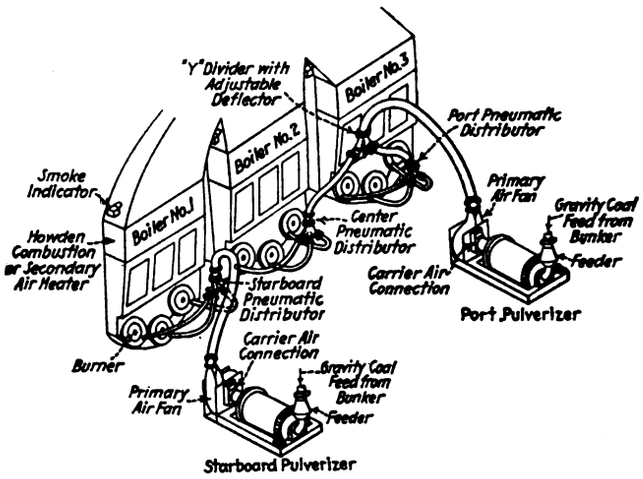

Fig. 1.—Arrangement of pulverized-fuel equipment on the Mercer

and for the eastbound passage of the fourth voyage. Our observations made on subsequent arrangements and on other installations force us to the conclusion that for consistent regular operation the arrangement of a pulverizer per boiler is the most satisfactory. Further subdivision of pulverized-fuel supply, such as a mill per burner, may prove to have still greater advantages. However, sea-going service tests will be required before a definite statement can be made regarding the merit of a greater number of units, but at least one mill per boiler should be used.

This arrangement was not without its disadvantages, for while with average grades of fuel it permitted comparatively easy steaming, with inferior grades of fuel having 12,500 to 13,000 British thermal units heat content it was necessary to force the combustion rates in the six furnaces beyond the point of their highest efficiency.

Moreover, the center boiler being dead and having no air current through it to supply the necessary velocity for sweeping away ash deposit, it was found at the end of fourteen days' steaming that the ash from the two wing boilers would settle down, fill the uptakes, smokeboxes and even tubes of the center boiler and make it necessary to clean the same thoroughly before it could be used for steaming when the vessel arrived in port.

As a corrective measure during the port lay between the first and second voyages, a damper was installed in the uptake of the center boiler. This did not prove effective, it being necessary to set up a gas current through the boiler of sufficient velocity to carry away the ash. It was found that a single oil fire in the center boiler would accomplish the desired result. Voyage No. 3 and the eastbound passage of Voyage No. 4 were therefore made with the port and starboard boilers fired by pulverized coal and a single oil fire carried in the center boiler.

In the meantime, experiments had been carried on at the Fuel Oil Test Plant with various types of distributors as described later, and a pneumatic distributor had been developed which gave the most satisfactory universal service. The pneumatic distributors were installed prior to Voyage No. 4 and proved so satisfactory on the eastbound passage of Voyage No. 4 that the operating personnel decided to modify the installation to permit the firing of pulverized fuel in the center boiler.

The modified arrangement is shown in Fig. 1. It will be noted that with the modified arrangement the port mill feeds the port and center boilers, while the starboard mill feeds the starboard boiler.

With this arrangement, the feeding of six furnaces by a single mill produced a primary-fan load which required higher fan speeds and discharge pressures than were considered satisfactory for continuous service. Therefore, only two of the furnaces of the center boiler are fired—or eight out of the nine furnaces are fired with pulverized coal while the ninth furnace is dead.

Deductions From Mercer Operation

The year's operating service of the *Mercer* has brought out several salient points that must be observed in effecting a satisfactory installation of pulverized fuel in Scotch marine boilers, which may be summarized as follows:

(*a*) Considerably finer pulverization of fuel is required than that necessary with large refractory-lined furnaces such as found in shore plants.

(*b*) High turbulence of flame is required to produce complete and rapid combustion necessary in the comparatively short flame travel characteristic of a Scotch boiler.

(*c*) Consistently uniform distribution of pulverized fuel between various furnaces of a Scotch boiler is necessary to maintain efficient performance.

(*d*) The power plant incident to producing pulverized fuel must be of an economical type, which may be secured either by installation of efficient low water rate units, or by useful employment of exhaust if less efficient units be used.

(*e*) Extra precaution must be taken to secure dust-tight smokebox doors and uptakes; otherwise, when using soot blowers it will be impossible to maintain a satisfactory fireroom condition.

(*f*) The velocities of the coal stream throughout the cycle require special consideration to prevent overloading of fans and coal precipitation in pipe lines and to secure satisfactory selection of superfine grind from mill and turbulence at burner.

(*g*) Personnel must be trained to give the same close supervision to velocity as is required in regard to viscosity and pressures when using fuel oil.

(*h*) The usual fireroom instruments, such as orsat and pyrometer, are important, but of greater importance are the draft gage and smoke indicator.

(*i*) Sized coal, or 100 percent slack coal, gives more uniform operating conditions that will run-of-mine; in fact, bunkering with run-of-mine will require use of crushers to produce fuel having a limited maximum size, otherwise, the feed to the mill will be very irregular, a condition that will be reflected throughout the whole operation of the boiler plant.

Installation on the Lingan

The second sea-going vessel to be fitted with pulverized fuel is the collier *Lingan*, operated by the Dominion Coal Company, Ltd., in the coal trade between Nova Scotia and St. Lawrence River ports.

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The general arrangement of the pulverized-fuel plant on the *Lingan* is shown on Fig. 2. In many ways this installation is similar to the original arrangement of the *Mercer,* the chief difference being that, in lieu of a main distributor, Y branches with adjustable deflectors have been used.

The piping arrangement of the *Lingan,* while not giving absolutely satisfactory distribution between the three boilers, has, however, given a workable arrangement that permits operation of the two mills in parallel. The complexity of piping, however, does create a rather severe primary-fan load.

The chief objective of the *Lingan* was to develop a mechanical means of firing a type of fuel which has given considerable trouble when used on stokers. This it has successfully done as the vessel has operated throughout the season using the very high volatile Noxa Scotia coal.

It was found that the coal in a pulverized form was highly inflammable, and considerable difficulty was at first experienced in preventing the coal from igniting in the burners themselves rather than in the furnace. The

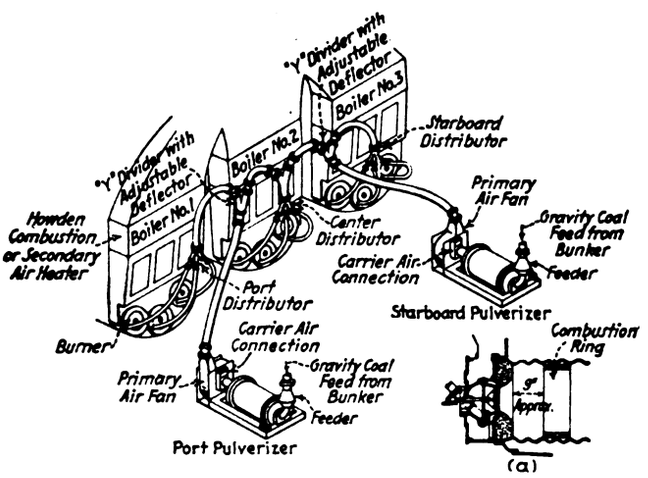

Fig. 2.—General arrangement pulverized-fuel equipment on the steamship Lingan

difficulty was overcome by modifying the furnace arrangement approximately as shown in Fig. 2 (a), by moving the combustion ring further into the furnace and so leaving an exposed water-cooled section of the furnace close to the burner, thereby retarding ignition sufficiently to prevent burning back.

First British Marine Installation

During the past year the first British installation of pulverized fuel on shipboard has been made.

For experimental purposes one single-ended four-furnace Scotch boiler on the steamship *Stuartstar* was fitted with pulverized-fuel equipment and operated with pulverized coal on the round trip voyage from England to the River Plate and return, a distance of approximately 13,000 miles and a total steaming period of about forty-four days.

The results of the trial installation justified extension of the pulverized-fuel plant. Therefore, on the vessel's return to England one double-ended eight-furnace boiler was fitted to use pulverized coal. The completion of the second installation gives a 50 percent conversion, as the total boiler plant of the *Stuartstar* consists of two single and two double-ended boilers.

A notable feature in connection with the extension program is that the conversion of the second boiler was completed in seven days. It is also to be noted that this is the first double-ended boiler installation that has been attempted.

The equipment employed on the S. S. *Stuartstar* consists of a Clarke-Chapman high-speed mill, per boiler, the burners being the Woodeson type, fitted into Howden forced-draft fronts, the furnaces being lined on the lower section with refractories.

It is reported by W. A. Woodeson, director of Clarke, Chapman and Company, Ltd., that the initial voyage was made with an inferior grade of fuel, Northumberland unwashed slack containing 14 percent ash, the fusing point of which was approximately 2000 degrees Fahrenheit. As the furnace temperature averaged about 2550 degrees Fahrenheit, considerable slagging naturally occurred, which necessitated slag removal every few hours, but did not interfere with continuous operation.

Sea Service Tests

The reliability and safety of pulverized fuel have been thoroughly demonstrated by actual sea operation of the three sea-going installations cited, also by the performance of the towboat *Illinois,* which has been in operation approximately eighteen months on the Mississippi River.

The ability to use satisfactory fuels which could not be used otherwise in a Scotch marine boiler has likewise been definitely demonstrated.

The economic possibilities have been indicated, and the problem in relation to adapting pulverized fuel to marine practice has been crystallized.

Real definite progress has been accomplished. However, the final standard type of installation still needs to be worked out.

Conversions and new installations now being made will further the development of the art and aid towards transforming it from an art into a fixed science having definite laws that can be employed with confidence by marine engineers.

Development Work

One of the most difficult problems encountered in the firing of a three-furnace boiler with pulverized coal similar to the boilers on the *Mercer* and at the Fuel Oil Testing Plant at the Philadelphia Navy Yard has been proper distribution, and a vast amount of time has been devoted to its solution at the Testing Plant. It is a comparatively simple matter to convert one stream of coal and air into two equal streams, but when an attempt is made to subdivide it into three equal streams it becomes a real problem. This is largely due to the fact that the mixture of air and coal passing through the single pipe is not homogeneous throughout the length of the pipe or across its section and the non-uniformity varies with changes in air and coal rates and also along the length of the pipe. About twenty different types of distributors were made and tried out. To attempt a detailed description of each of these would entail too much time, and therefore only a brief description of the most promising is given here.

The ones which presented greatest promise of satisfactory operation were the rifled cone and the pneumatic distributor. The rifled cone had the advantage of requiring no auxiliary power to operate it, but it was not entirely satisfactory throughout the range of rates run. It consists essentially of a truncated cone, flanged at each end so that it can be bolted in the primary piping. In the interior are welded fins or plates in the form of helices, the idea being that as the stream of air and coal pass through the distributor it be given a

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whirl, which breaks up any stream-line properties it might have gained, and that this whirl will continue up to the time it is divided by entering the three feeder pipes.

The pneumatic distributor was finally decided upon as the best developed for universal service to date, and, as previously stated, this has been installed on the *Mercer*. This distributor is very simple and embodies the principle of the rifled cone in that it imparts a whirl to the coal and air stream but has the added advantage of permitting adjustment for various rates and conditions.

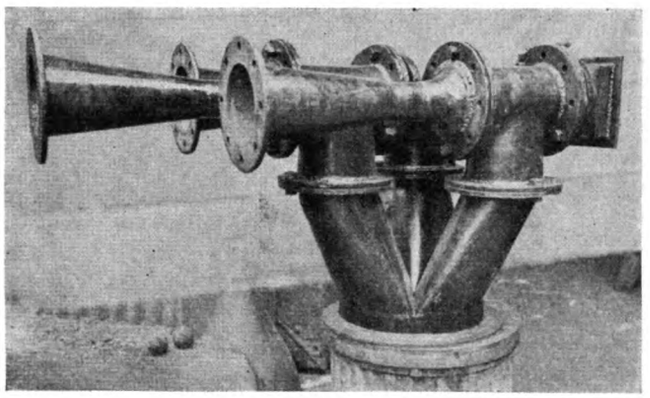

Fig. 3.—Side view of Blo-gun

It consists of a circular disk the inside diameter of which corresponds to the diameter of the pipe and through which are drilled tangential orifices connected to a source of compressed air. When air is turned on, it forms a whirl on the inside and has the effect of imparting a spiral flow to the coal stream. By varying the pressures in the orifices the stream of coal and air can be spiraled so as to give equal flow through each of the three feeder pipes.

Early in the operation of the *Mercer*, it became apparent that consideration must be given to the correction

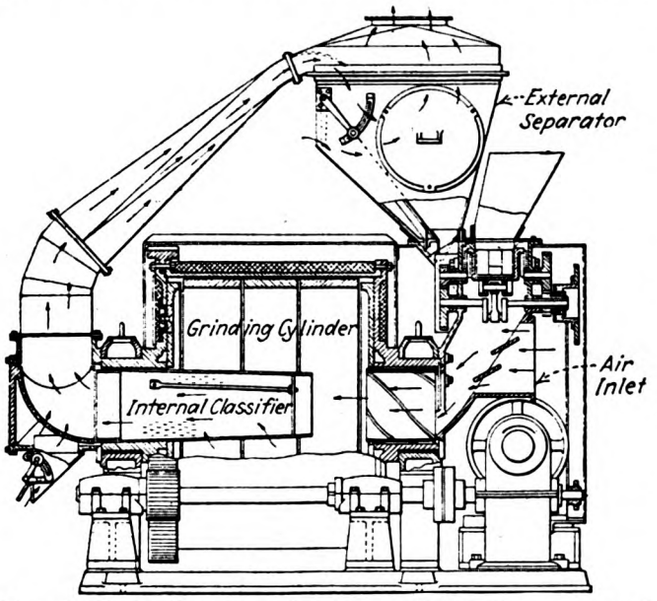

Fig. 4.—Fuller-Bonnot pulverizing unit of the worm and gear driven type

of fan-blade erosion which extends beyond the fan itself, inasmuch as erosion is not uniform and an unbalanced high-speed fan quickly sets up vibrations which may prove very serious to the fan drive.

There are several methods of attacking the problem, as, for example:

(*a*) Use of forced draft instead of induced draft for the air sweeping the mill.

(*b*) Use of special materials for manufacture of fan blades.

(*c*) Use of comparatively cheap and easily renewed rotor.

(*d*) A fourth method is to apply the ejector principle, which has been attempted at the Test Plant by the use of the so-called Blo-Gun.

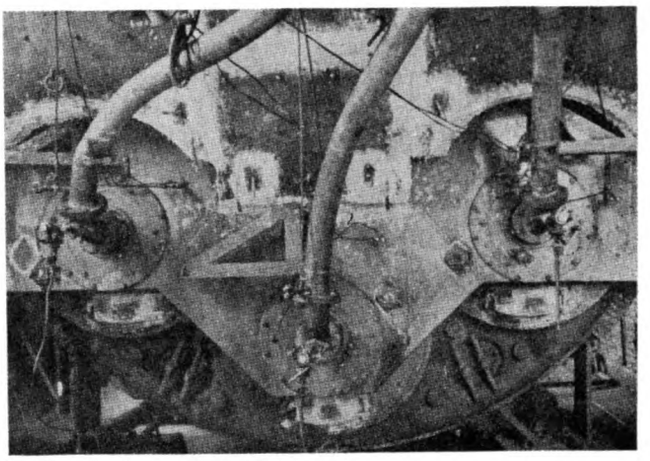

Fig. 5.—Pulverized-coal Lodi burner installation

In attacking the problem of fan erosion, the engineers of the B. T. Sturtevant Company were called into consultation, and the Blo-Gun, as finally evolved, is the result of their co-operative effort.

The Blo-Gun as finally built is shown in Fig. 3. The principle of the device is to create a partial vacuum by means of a high-velocity air current discharging from a nozzle across an enlarged chamber into a venturi throat. The partial vacuum sets up an air current which sweeps through the pulverizer, picking up the finely pulverized fuel and carrying it into the mixing chamber, where it joins with the stream of injection air and forms the total primary air and coal mixture going to the burner.

The Blo-Gun requires service tests to determine its real merit. It has been included in this record, however, as it is a new method of attacking one of the serious problems characteristic of pulverized fuel.

The Fuller-Bonnot Mill and Lodi Burner Tests

It was considered desirable to try out on a Scotch boiler the pulverized-fuel equipment that Mr. Stillman used for the tests on a Babcock & Wilcox boiler as described in his paper before the society last year.

To this end, during the early part of this year, the Lodi burners were installed on the Test Plant Scotch boiler and the Fuller-Bonnot mill was set up.

The mill and burner used for this test installation were the same as that described by Mr. Stillman in his paper, except that the burners were fitted in a forced-draft double front and supplied with pre-heated secondary air instead of being operated with natural draft.

The Fuller Bonnot slow speed ball mill as shown in Fig. 4, is equipped with internal and external separator or classifier. The external classifier returns for regrinding any coarse particles of coal which may have passed through the mill.

The burner installation on the Fuel Oil Testing Plant boiler is shown in Fig. 5, from which it will be seen that it is quite compact and makes a nice job. Provision is made for swinging out the burners for the purpose of getting to the furnaces and it will also be noted that slag doors are provided at the bottom.

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Early operation of this equipment showed it to be satisfactory for use with Scotch marine boilers, and as efficiency characteristics had been worked out at the Bayonne tests, and as the question of developing a sea-going distributor was paramount, it was decided that, instead of conducting orthodox efficiency tests, the equipment should be used for testing out the various types of distributors.

The distributor tests did, however, permit the taking of a considerable amount of operating data from which the characteristic form of the boiler-efficiency curve, when using this equipment, could be determined as well as its relation to the curve obtained at the Bayonne tests.

The test runs were of comparatively short duration, being only from two to six hours. Therefore, it is not possible to present a complete tabulation of performance as was made for the 240-hour test run with definite assurance that the values so given would represent operating conditions such as would be met in service, inasmuch as coal-burning tests of less than eight hours' duration are justly subject to criticism.

As stated above, however, there was a vast amount of data for short runs, which data have been averaged and

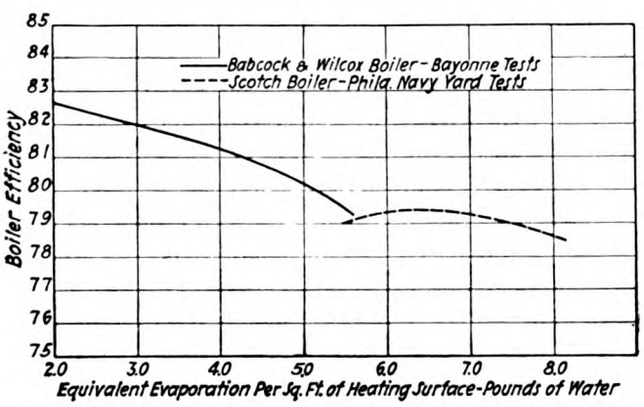

Fig. 6.—Boiler efficiency curves Fuller-Bonnot mill and Lodi burner

from which a boiler-efficiency chart has been plotted as shown on Fig. 6.

On Fig. 6, are also plotted the results obtained at the Bayonne tests made on a Babcock & Wilcox boiler with this same equipment. It is significant in comparing the two series of tests that the Scotch boiler tests start at approximately the same rate of evaporation as that which marks the maximum rate obtained on the water-tube-boiler tests.

It will be noted also that the efficiency at the maximum watertube-boiler rate and the minimum Scotch boiler rate are approximately the same and that the efficiency curve for rates of evaporation from 5.4 pounds to 8.1 pounds per square foot of heating surface is quite flat, the total variation being approximately 1 percent.

Todd Burner Pulverizer

The completion of the tests of the previously mentioned equipment has, through the courtesy of the Fuller-Lehigh Company, been temporarily postponed in order that the facilities of the plant could be utilized for trying out an entirely new type of installation, an installation which provides a complete pulverizer and burner per furnace.

The Todd Dry Dock and Engineering Corporation, which produced this new system, has carried on considerable development work, using a small two-furnace Scotch boiler at the Tebo Yacht Basin plant. The company did, however, desire to apply the equipment to a full-sized boiler where a complete test could be made, and as the system has several characteristics which make it desirable for sea service, arrangements were made for its installation at the Test Plant.

The operations of feeding, pulverizing and furnishing the necessary primary air for combustion are comprised in one unit which also embodies the coal burner, air

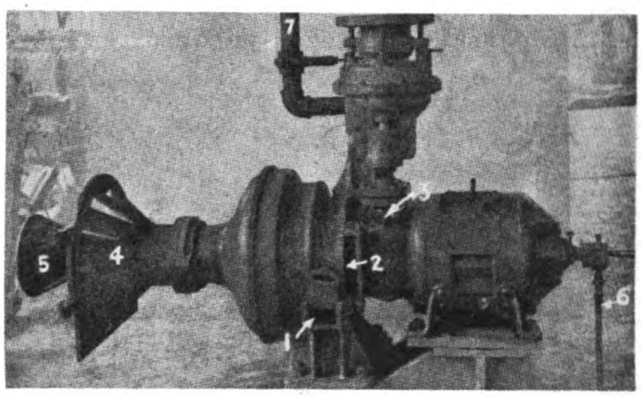

Fig. 7.—Todd pulverized-coal burner

register and a fuel oil atomizer as an auxiliary. The unit is very compact in design, as will be seen from a study of Fig. 7. Fig. 8 shows an installation for three furnaces as installed on the test boiler at the Fuel Oil Testing Plant.

The pulverizer is a two-stage impact type, rotating at a constant speed of 3600 revolutions per minute. The entire unit is driven by a 10-horsepower motor. There is a fan for supplying the necessary primary air at the front end or just beyond the second stage rotor. The coal is fed into the pulverizer through suitable piping onto a rotating feeder disk driven by the vertical shaft,

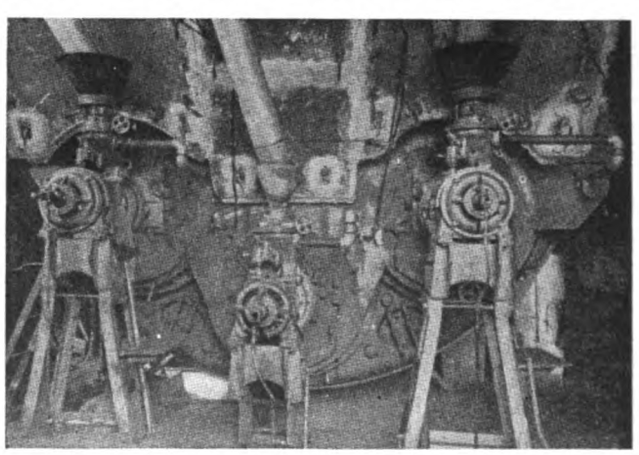

Fig. 8.—Todd burner and pulverizer unit installation on a Scotch marine boiler

mark 3 of Fig. 7. Adjustment of the feed is made by a knife, the position of which is controlled by a small hand-wheel. Any piece of foreign or tramp metal which may have passed the feeder is thrown out by centrifugal force in the first stage and is removed at the tramp metal clean-out door. Primary air is supplied through connection 7, which is led from the air preheater and/or through opening 2, both of which are adjustable. The mixture of air and coal is forced out by the action of the primary-air fan through a 5-inch discharge pipe connecting the air cone 4 and the mill.

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This mixture is given a whirl by the flame cone 5, thus creating the necessary turbulence. Secondary air, supplied through the slotted air cone 4, is also whirled, supplying the additional turbulence required.

The unit has been designed for installation in a Howden coal-burning double front and only minor changes are necessary.

This equipment is now under test at the Fuel Oil Testing Plant and while no completed data have been obtained as to its operation, preliminary results have been very satisfactory. All three units have been in successful operation at the same time and although some difficulties have arisen, these are being worked out and indications are that the equipment will be successful. Very complete combustion is possible at rates from approximately 200 pounds to over 600 pounds per unit per hour, with very little or no smoke and high CO_2.

Welding Applied to Shipbuilding*

Outline of welding processes adaptable to ship work—Weight and cost savings analyzed

By James W. Owens†

PRIOR to 1918, the use of the pressure and fusion-welding processes in new construction was practically unknown, the various welding processes Fig. 1, with the exception of forge welding, being employed almost exclusively for emergency repairs, and even then their application invariably depended on the judgment of the practical welder or the salesman, as few men were available who could be classed as welding engineers. During the few years which have elapsed, this situation has rapidly changed, for the pressure and fusion-welding processes have revolutionized industries as completely as the use of metal revolutionized ship construction. Practically every issue of the technical press records new applications of welding to building construction, bridge construction, ship construction, pipe-line construction, machinery construction, etc.

The German and American navies are using welding extensively on new construction; and the Newport News Shipbuilding and Dry Dock Company is now employing approximately 100 arc welders on ship construction, ship repair and other classes of structural work, with a daily consumption of electrodes of almost 1,000 pounds.

Last year, the Navy Department issued specifications covering the use of metal arc and gas welding on vessels of the United States Navy, and the American Bureau of Shipping revised their rules so as to permit the construction of completely welded ships.

Although metal arc welding is the process most extensively employed in ship construction and repair, I regard it as scientifically undesirable to consider it to the exclusion of the other welding processes, and, before taking up specific applications, will therefore briefly classify and describe each process, giving reasons for its suitability or unsuitability for ship construction and repair.

Reference to Fig. 1 will show that welding is divided into three main processes—forge, pressure and fusion, the principal difference between these processes being that in forge welding the weld is in general completed by the application of a hammer blow; in pressure welding, by means of mechanical pressure, and in fusion

* First installment of a paper presented at the thirty-sixth general meeting of the Society of Naval Architects and Marine Engineers, held in New York city, November 15 and 16.

† Director of welding, Newport News Shipbuilding and Dry Dock Company, Newport News, Va.

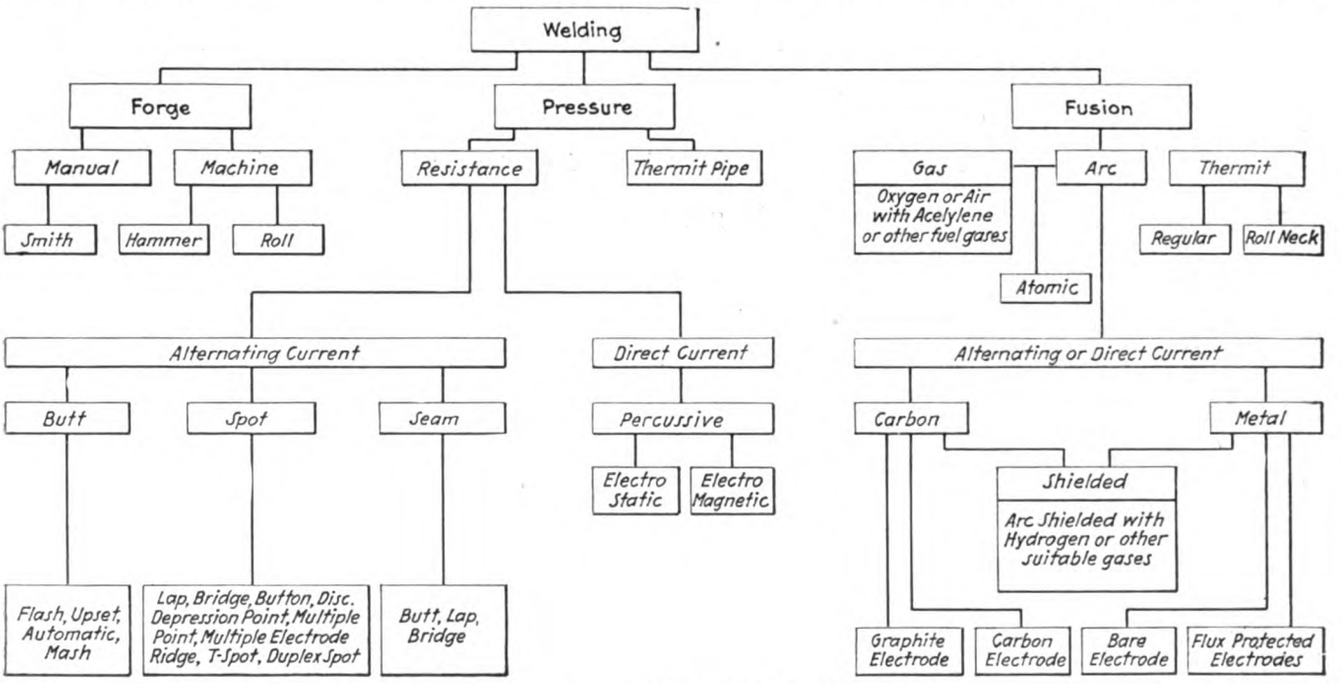

Fig. 1.—Diagram of grouping and interrelation of various welding processes

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welding without any mechanical means. The temperature at which the metals are united also differentiates these three processes, for, with few exceptions, the metals are, in forge welding, in the plastic state; in pressure welding in the plastic or molten states; and in fusion welding in the fluid and/or vapor states. The following definition of a weld has been tentatively approved by the Nomenclature Committee of the American Welding Society: "The localized intimate union of metal parts in the plastic and/or molten states with the application of mechanical pressure or blows; and in the molten or molten and vapor states without the application of mechanical pressure or blows."

Forge Welding Processes

The forge welding processes are the manual smith or blacksmith weld and the machine smith or hammer and rollneck welds. These processes have been extensively employed in the past in ship construction and repair; however, blacksmith welding has, in recent years, been largely supplanted by gas and metal arc welding for anglesmith work in general; and the machine smith weld, because of its high cost and limited application, is destined to be gradually supplanted by the thermit, gas, arc and resistance butt welding processes.

Pressure Welding Processes

The pressure welding processes are the resistance butt, spot and seam welds; the percussive weld, and the thermit pipe weld. Resistance spot welding is particularly applicable to the welding of light galvanized sheet metal and light black sheet metal when repeat production is possible; for example, vent ducts. When satisfactory spot-welding machines of large K.V.A. capacity are developed, it should be possible to economically use them for heavy material. Resistance butt welding is not at present used in ship construction and repair; however, it is believed that it would be very economical to employ it for the welding of coaming angles and stapling of all sizes. Resistance seam welding is economical on light black sheet metal and aluminum, where tightness is essential and repeat production possible. Thermit pipe welding has not as yet been employed in the piping installation of ships; however, excellent and economical welds can be made by this process in pipes up to 6 inches in diameter. The percussive welding processes appear to have no immediate field of usefulness in ship work.

Fusion Welding Processes

The principal fusion welding processes are the gas weld, the metal arc weld, the carbon arc weld, the shielded carbon and metal arc welds, the atomic weld and the thermit weld. The atomic and shielded-arc welding processes have not been used in ship construction and repair; it is probable, however, that in the future steps will be taken to utilize these processes in view of the excellent ductility of welds made by them.

Gas Welding and Cutting Processes

The gas welding process is unexcelled for cast-iron welding, when the job can be preheated; for the welding of light black sheet metal; all of the non-ferrous metals; and for brazing and the building up of cast iron with a bronze filler rod, when localized preheating is desirable and permissible. It is also used for the welding of wrought iron and steel, when not a part of the ship's structure, e.g., tanks and piping; and steel requiring forging after welding, e.g., stapling and coaming angles. As the cost of welds made by this process is usually greater than that of metal arc welding, its use is not extensive for work on which metal arc welding is satisfactory. On non-ferrous metals, it is now used extensively in the repair of broken propeller blades. Gas welding is not suitable for hull construction or any structure in which there is considerable rigidity, because the large area of the flame produces tremendous heating and cooling stresses, which either warp the structure or cause the joint or some other part to fail. Welding rods have recently been developed by the Linde Air Products Company with which welds of excellent ductility and high tensile strength can be obtained.

The gas cutting torch is probably even more essential than the gas welding torch in ship construction and repair, and it is believed that with a more extensive application of welding to ship construction, the mechanically-operated cutting torch will be more generally used than at present; in the repair to damaged welded structures; the accurate cutting to size of parts to be welded; the manufacture of pipe flanges from plate material; and the cutting of heavy sections, thereby reducing forging to a minimum.

Thermit Welding Process

Thermit welding is particularly suitable for the manufacture and repair of heavy sections such as anchors, gudgeons, rudder posts and stocks, propeller shafts, crank shafts, stems, stern frames, etc. For the welding of heavy sections, the thermit welding process has an advantage over many of the other welding processes in that the entire weld being made simultaneously, there is but one shrinkage and the operation is largely mechanical. A thermit weld is superior to the manual and machine smith welds and the riveted scarf now used. Improvements in technique recently made by the Metal and Thermit Corporation make it economically possible to use it for new work. The thermit and resistance butt welding processes will no doubt eventually supplant the machine smith weld in the fabrication of large sections.

Carbon Arc Welding and Cutting Processes

While excellent wrought-iron and steel welds can be made with the carbon arc process, nevertheless, like the gas process, its use will probably be restricted for hull work due to the tremendous heating and cooling stresses produced, and the difficulty of suitably applying filler metal in many forms of joints. On the other hand, for sub-assemblies in the shop and on the skids, and with suitable forms of joints, its use would be practical and economical. It has been used for the welding of barges of channel construction, pipe lines, tanks, castings and some building-up operations. It can also be used to a limited extent for the welding of some non-ferrous metals. Rough economical cuts can be made in sheet steel not exceeding ¼ inch in thickness, and in cast iron and the non-ferrous metals.

Metal Arc Welding Process

The direct-current metal arc welding process, when compared with the other welding processes, offers the greatest field of usefulness in the construction and repair of the ship's hull and machinery. Alternating current may also be used, but the writer does not recommend its use for the strength joints of a ship because, among other reasons, the instability of the arc requires the use of a higher open circuit voltage than direct current, thus introducing an element of danger to the welder; and satisfactory overhead welds cannot be

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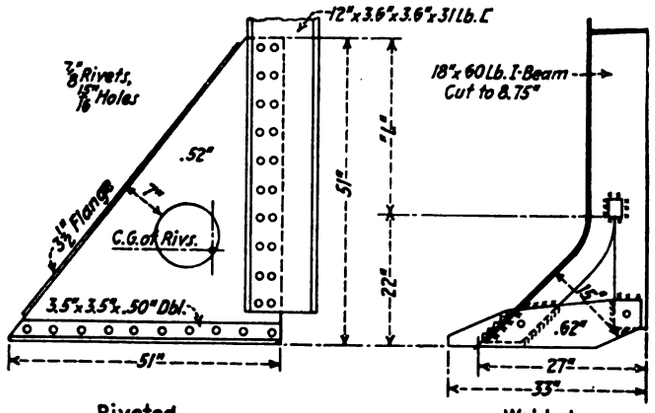
made unless the electrode is provided with a flux coating or covering. Some makes of fluxed and covered electrodes will produce welds with a greater deposition rate than with bare electrodes and with a minimum of porosity. However, as their use might increase the cost of welding, it is recommended that a thorough test be made before authorizing their general use. Covered electrodes are used more extensively in England than in America, and their high cost, as compared with bare electrode, is undoubtedly one of the reasons why the development of welding in ship construction has been retarded in England. Bare electrodes were used in the construction of the new German cruisers.

Metal arc welding should, in general, be used for the welding of all low and medium carbon steel plates,



	Riveted	Welded
	Riveted 339 Lb.	Welded 97 Lb.
Weight of Bracket	2,420,000 Lb.	2,420,000 Lb.
Ultimate Resisting Moment of Frame	2,640,000 Lb.	3,110,000 Lb.
Value of Bracket in Compression	4,650,000 Lb.	5,110,000 Lb.
Value of Bracket in Tension		

Saving in weight of welded bracket over riveted bracket 71.4%

Fig. 2.—Comparative designs of frame brackets for riveted and welded ships

shapes, and pipes; low-carbon forgings and castings, less than approximately 3 inches square; and cast iron, if impossible or not desirable to preheat and studs can be employed.

Advantages of Metal Arc Welding

The three principal advantages to be obtained by the use of metal arc welding are reduced weight, reduced cost, and a better product. Bound up in these are several other advantages, such as high joint efficiency and tightness of joint, some of which are often of equal or of greater importance to the user than a saving in weight or a reduced cost of the product.

In the manufacture of pressure vessels, joints having an efficiency of 100 percent are frequently of primary importance; to the designer of naval ships, aircraft, and other mobile structures, a saving in weight counts more than first cost; and to the oil producer and ship owner, tightness of joint is just as important as first cost, as it materially reduces operating costs.

From the foregoing, it will be seen that the many advantages of metal arc welding give it a unique industrial, commercial and military value. Although the advantages of the process have not as yet been fully appreciated in ship construction and repair, nevertheless the process will undoubtedly ultimately revolutionize ship construction.

Savings in Weight

With the exception of aircraft, ships and rolling stock, the savings obtained by metal arc welding are, in general, restricted to first cost. The weight saved in a ship's hull and machinery, on the other hand, makes possible a greater carrying capacity, a reduction in the cost of operation, or an increase in speed, any one of which has a bearing on net income throughout the life of the vessel. In naval ships, the weight saved permits an increase in armor, armament, speed and cruising radius; these military characteristics have always been important, but weight is now more important than ever before, due to the recent treaties limiting the displacement of naval vessels. Savings in weight of 10, 20 and even 71.4 percent, Figs. 2 and 3, may often be obtained by the substitution of welded steel for riveted steel, and as high a percentage by the substitution of welded steel for iron castings. Savings in weight, although much

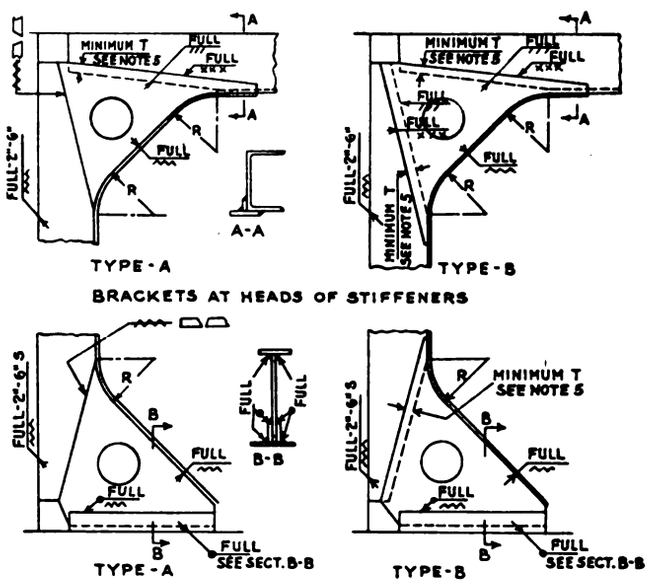

MINIMUM T SEE NOTE 5
FULL
R
A-A
TYPE-A
TYPE-B
BRACKETS AT HEADS OF STIFFENERS
B-B
SEE SECT. B-B
NOTE: BRACKETS AT HEELS OF STIFFENERS
1. T=Thickness of thinner section joined
2. R=Depth of stiffener but not less than 6"
3. Brackets drawn for built up stiffeners but may be used for shapes
4. Bracket plates to be neat fit to curvature of face plate or flange of shape
5. Where assembly holes are required use standard width of lap

Fig. 3.—Welded brackets at heads and heels of stiffeners

greater when welded steel is substituted for cast iron, are also obtained when cast steel is eliminated, for the uniformity of rolled or drawn steel permits the use of thinner material than if the article were made of cast steel. Due to the necessity of securing a maximum reduction in weight in aircraft construction, without a sacrifice of strength (which can be obtained by the use of arc and gas welding), there are very few castings used in this type of construction today.

By the substitution of welded steel for cast iron, the thickness of the metal can in general be made one-quarter that required for an iron casting; however, if stiffness is of primary importance, the welded steel should be approximately one-third that required for cast iron.

The writer recently prepared comparative designs of riveted and welded freighters of approximately 13,000 tons deadweight capacity in order to determine the maximum percent saving in the weight of the hull steel which could be secured with designs complying with the rules of the classification societies. It was found that it was possible, for the ship analyzed, to obtain a saving of 16.7 percent or 494 tons (2,944 — 2,450) in the weight of hull steel. It was also found that at a 31-foot 8½-inch draft, the deadweight capacity of the welded ship was 13,219 tons as compared with 12,719 tons for

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the riveted ship, or an increase in deadweight capacity for the welded ship of 500 tons or 3.9 percent.

Fig. 2 shows comparative riveted and welded designs of a frame bracket. Fig. 3 shows the latest development of brackets at the heads and heels of stiffeners, and which can be used instead of the frame bracket shown in Fig. 2. These designs clearly indicate the general principles of welded design and how it is possible, by the use of welding, to effect considerable savings in weight and cost.

The welded bracket Fig. 2, as designed, does not take care of the increased unsupported length L of the frame. This increased, unsupported length can be compensated for by the use of a tapered face plate on the frame for a short distance above and below the center of the span, or an increase of the depth of the frame from 8.75 inches to about 9.75 inches. It is believed that the first method is preferable, as it would save the maximum amount of weight and permit greater flexibility in design, the face plate only being used where absolutely necessary. The face plate might be eliminated under some conditions when stringers are used, or when the frames are materially stiffened by structural details within the ship.

Savings in Cost

Considering the cost of manufacture first, we find that by substituting arc-welded steel for riveted steel and castings, it is possible to effect savings in time and labor in every phase of the manufacture of a product—design, fabrication, sub-assembly and erection, provided the structure is specifically designed for welding. The principal savings by welding are made by proper design in the drawing room; therefore design problems should not be left to shop men. These savings start in the making of calculations of joint efficiencies and in the preparation of drawings. The calculations and drawings for welded structures are simpler than those of riveted construction. The elimination of the rivet schedule also saves considerable time.

Less time is usually required to produce a welded steel product than either riveted steel or cast products. Castings are usually the worst offenders. Exclusive of the time required to make the pattern, the normal time allowed by a foundry for making the mold for a steel casting and baking mold, pouring the casting and cleaning and annealing it, is two weeks. Any one of these operations may require twenty-four hours or more. This, of course, can be and is materially shortened in cases of emergency; nevertheless the making of a steel casting requires a considerable amount of time. In repair shipyards, delays from replacement of broken or defective castings by similar castings frequently require a ship to remain tied up for days, with losses due to fixed charges and cessation of earning capacity amounting to thousands of dollars per day. By the use of welded steel, such losses would be largely eliminated.

As welding makes possible a reduction in the total man-hours required in the various trades, there is also a corresponding reduction of overhead. A reduction in the stock of patterns and spare parts and capital invested in equipment are also features to be considered in the reduction of overhead.

Under "Savings in Weight," it was pointed out that the hull steel of the welded freighter analyzed was 494 tons lighter than that of a similar riveted freighter, which with steel at $45 per ton would amount to $22,230. Considering the cost of material and labor as related to the total cost of the ship, it was found that the material for the welded ship would cost 6.1 percent less and the labor about 5 percent less, the total cost of the welded ship (labor, material, overhead and a small profit) being approximately 3.7 percent less than the riveted ship.

Assuming that the cost per deadweight ton for constructing the 12,719-ton deadweight riveted freighter would lie between $50 and $100, regardless of when built, it was found that the savings at $50 per ton would be approximately $23,530, and $47,060 at $100 per ton. With this information available, and the cost per deadweight-ton for constructing riveted ships in a yard known, the cost of constructing a welded ship can easily be determined.

In a shipyard doing a twenty million dollar business annually, it has also been estimated that when ships are completely welded we will be able to obtain a saving of approximately 9 percent for the entire plant or $1,800,000 annually. When welding reaches this state of development, the savings effected by the welded construction of ships will be more than the 3.7 percent used in estimating the cost of the welded ship.

Thus far we have only considered savings in first cost, viz., savings related to manufacture. However, as previously pointed out, the greatest savings which welded construction makes possible in mobile structures are operating costs, and for this reason the analysis of the riveted and welded ship was considered further to determine the savings in the cost of operation which shipowners and operators will be able to effect by having their ships completely welded. This was found to be approximately $2.47 per gross ton per year or $111,150,000 per year if all the freight ships of the world of over 1,000 gross tons were welded. To put it another way, the welded ship owner can charge 5 to 6 percent less for carrying cargo and yet pay the same percentage in dividends as the riveted ship owner, or have this added earning capacity for increased dividends.

The elimination of leaky riveted connections is one of the principal items involved in lowering cost of upkeep by welding.

Actual and estimated savings in weight and cost obtained in ship construction are given in Table 1.

TABLE I—ACTUAL AND ESTIMATED SAVINGS IN MATERIAL AND IN THE COST OF VARIOUS PARTS OF SHIPS

Item	Part of ship	Construction: No. made	Construction: Weight each lbs. Riveted	Construction: Weight each lbs. Cast	Corresponding welded construction: No. made	Corresponding welded construction: Weight each (lbs.)	Percent saving: Wt.	Percent saving: Labor	Percent saving: Cost	Remarks
1	Bilge keels		38,400			26,400	31.0	20.9	28.0	
2	Masts		27,500			22,500	18.2	15.7	15.7	Lower mast only
3	Pillar connections	1	130		1	130		75.0	75.0	15-inch dia. pillar used
4	Battle towing target	2	103,000		2	90,670	11.9		25.6	
5	Independent tanks	2	9,700		2	8,000	17.5	31.0	25.7	
6	Rudder		26,500			24,200	8.7	3.5	22.0	
7	Frame bracket		339			97	71.4	43.0	50.0	
8	Average		29,367			24,574	16.3	18.4	21.9	
9	Condenser shell and heads	1		22,400		11,500	48.6	- 11.2	22.5	Welded condenser has cast iron heads
10	Hawse pipe	2		9,160		6,280	31.5	15.3	42.0	

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Welding to Obtain a Better Product

In order to obtain a better product, it is essential that material suitable for welding be used, that joints are properly designed, and that welds are made in a plant with an efficient shop organization.

In Captain Caldwell's report, submitted to the Emergency Fleet Corporation in 1918, on the "British Admiralty's Investigation in Electric (Metal Arc) Welding," we find these two pertinent statements:

"The low stresses at which the seams open indicate that, unless we can effect some improvement over riveting, we cannot utilize to the best advantage the material at our disposal and indeed suggest that we have already reached, if not exceeded, the stresses that riveted joints can stand with safety." In this connection, tests have shown that slippage occurs in riveted joints at 15 to 20 percent of their ultimate strength, or less than one-half the elastic limit of the material, thus breaking the calking edge and permitting leakage to occur.

"The Admiralty are quite satisfied that arc welding is at least equal, if not superior, to existing means of connecting two portions of the ship's structure or for making good a defective casting and corroboration of this view is continually being brought to notice." The maximum efficiency of a rivietd joint in tension, as given in the United States Navy Department's Specifications, is 89 percent, whereas efficiencies up to 100 percent can be obtained by arc welding, these efficiencies being based on the unwelded base metal. The presence of rivet holes always decreases the defective section of the joint, and their presence tends to cause leaks.

(To be continued)

The 19,000-Ton Liner Kungsholm

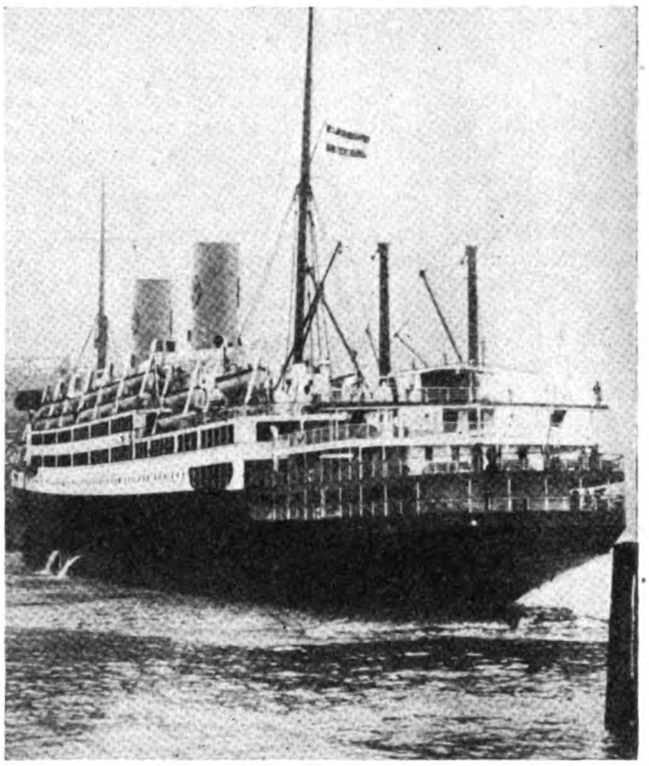
THE second transatlantic passenger liner, the *Kungsholm,* built for the Swedish American Line's regular service between Gothenburg and New York, was completed at Blohm & Voss's Hamburg yard late in October. The vessel then proceeded on her preliminary trial, which was successfully carried out, a speed of 19.8 knots being attained. On the return trip to the harbor there was an explosion in the crank chamber of the starboard engine, with serious results, a number of men being killed and injured. Although explosions in crank chambers of Diesel engines are not unknown, no serious accident of this sort has ever before resulted.

It is generally believed that the explosion was due to an accumulation of oily vapor within the crank chamber, possibly owing to hot bearings, and that by some means this vapor became ignited. The finding of the court, which will hold an investigation on the matter at Hamburg, will be of the greatest interest to engine builders, as well as to shipowners. Curiously enough, the engine sustained comparatively little damage and a temporary repair was rapidly made. Permanent repairs were carried out at Copenhagen in order that the vessel might not be delayed on her maiden voyage, scheduled for November 24 from Hamburg.

Largest Swedish Ship

The *Kungsholm* is the largest Swedish ship, being substantially larger than the *Gripsholm.* She is 608 feet 4 inches in length, with a beam of 78 feet 1 inch. Her service speed will be 17½ knots.

The Burmeister & Wain engines of which there are two are in general similar to those on the *Gripsholm.* In fact the cylinder dimensions are the same, but there are eight cylinders instead of six, 840 millimeters bore, with a piston stroke of 1500 millimeters. An output of 7500 brake horsepower per engine is attained at 100 revolutions per minute. The injection-air compressors



Swedish Line motorship Kungsholm

are, however, separately driven, being installed in the auxiliary engine room, together with the Diesel-driven generators.

The accommodations of the *Kungsholm* are even more luxurious than on the *Gripsholm.* The vessel will carry more passengers, namely 230 in the first class, about 400 in the second class and nearly 1000 third class passengers.

M. S. Courageous Completed

THE M. S. *Courageous,* first of three cargo vessels to be converted by the United States Shipping Board to Diesel-electric drive, was given its "shake down" trials November 26. The work of converting the *Courageous* was done by the Federal Shipbuilding Company at Kearney, N. J., from specifications prepared by Gibbs Brothers, Inc., New York.

The new power plant consists of four 1280-horsepower, four-cycle, air-injection Diesel engines furnished by the McIntosh & Seymour Company, each direct connected to two electric generators, one supplying power for propulsion and the other for excitation, auxiliary power and lighting. Complete electric equipment for this vessel was furnished by the General Electric Company. The main generators are four 800-kilowatt units, while the auxiliary generators are four 100-kilowatt machines. The propulsion motor is a double-unit type, consisting of two motors on the same shaft, each rated 2,000 horsepower.

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Shipping Board Motorship Records*

Analysis of operating and fuel performance data of twelve vessels converted to Diesel drive

By Captain R. D. Gatewood (CC), U. S. N.†

SINCE the presentation of the paper entitled "The Engines of the United States Shipping Board Diesel Conversion Program," before the Society of Naval Architects and Marine Engineers at its meeting last year, each of the twelve vessels which were converted has sailed at least 13,000 miles, and many of them have considerably greater mileage than this to their credit. It is therefore possible in this paper to present data not only of interest to manufacturers and designers but also of value to operators.

Maintenance

In reference to maintenance costs, which of course are of great importance to the operator of cargo vessels, it is felt that the period of operation of these twelve vessels has not been long enough to establish reliable figures. In each of the various types, we have found it necessary, in drawing up our specifications for the second part of the Diesel conversion program (which consists of eight vessels), to call for changes in the engine that will incorporate improvements developed in practical service.

For example, in the Busch-Sulzer engine, changes are called for in the design of pistons, telescopic piping, framing joints, etc. In the McIntosh and Seymour engine, changes are called for in pistons, piston rods, exhaust valves. In the Worthington engine, changes are called for in the piston rods, cylinder liners, cooling-water system. In the M.A.N. engine, changes are called for in the design of pistons and the elimination of entablatures, which necessitates considerable alterations in engine design so as to economize in the construction of this engine.

The actual detentions at sea, that may be charged to equipment installed at the time of Diesel conversion, which have occurred on the twelve vessels during the twenty-six voyages that they have made up to the time this paper was written, amount to only 408 hours or less than one percent of the 46,941 total hours these vessels were at sea (Table 1). The detentions have been due to several causes, such as steering-engine trouble, silencer, contaminated fuel, piston rods and cooling systems, the majority of the detentions, being due to cooling-system troubles.

It has been our observation, in studying the operating performance of the numerous vessels of the government fleet, that when a vessel is taken out of lay-up and put into commission it requires approximately fifteen months as a shake-down period before consistent economical performance is obtained. It is felt, however, that the results shown in this paper can be taken as a fair indicator as to what should be expected. In the case of these vessels we have a much less transient crew than would be found on the ordinary vessel taken out of lay-up, as a very careful selection was made at the time of appointing the personnel. It is to be noted that with a possible turnover of 56 engineers there has actually been a turnover of 36, of which 12 were promotions either to a higher rank or to a shore station and 13 were in the rank of third assistant.

The characteristics of the various types of main engines installed on these vessels, together with details of auxiliary machinery may be obtained from articles published in MARINE ENGINEERING AND SHIPPING AGE at the time the conversion work was completed.

With the exception of the first voyage of the *Tampa* and the *West Honaker*, the initial voyage of each of these vessels has been anywhere from approximately

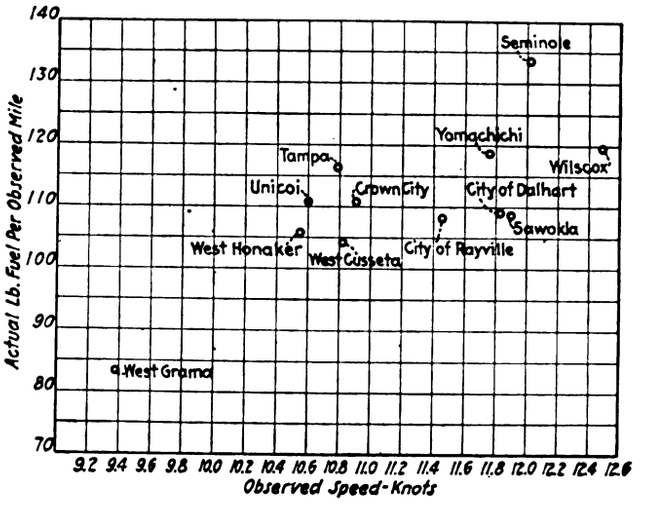

Fig. 1.—Actual average fuel performance of Diesel converted vessels

13,000 miles up to 28,100 miles. The twenty-six voyages made by the vessels include three to Europe, four to the east coast of South America, eight to the Far East, and eleven around the world. The *West Grama*, which had made only one voyage at the time of writing this paper, has traveled 12,982 miles. The total mileage for the entire twelve vessels is 545,852 miles. It is to be noted that these vessels have been consistently kept in long-distance trade routes, as it is in this particular service that the Diesel has demonstrated its greatest value by its ability to bunker sufficient oil for long journeys at such points where fuel can be secured at a low price and at the same time not interfere greatly with the cargo-carrying capacity of the vessel.

Wage Schedules for Steam and Motor Vessels

As a means of comparing the wage schedule of the motorships with similar type cargo boats, Table 2, has been prepared. It is to be noted, in referring to this table, that in the government fleet all of the hand-fired coal vessels are fitted with Scotch boilers, which have the water gage glasses in the engine room, and water tending is carried on by the engine-room force. Therefore no water tenders are carried and the total wage scale for our hand-fired coal vessels is $1,765.00 instead of

* Abstract of a paper presented at the thirty-sixth general meeting of the Society of Naval Architects and Marine Engineers, held in New York city, November 15 and 16.

† Manager, Maintenance and Repair Division, United States Shipping Board, New York city.

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Table 1.—Detentions Due to Diesel Conversion Casualties

Motorship	VOYAGE 1 Hours: Total at Sea	Hours: Detention	% Sea hrs. lost by detentions	Detentions: No.	Reason	VOYAGE 2 Hours: Total at Sea	Hours: Detention	% Sea hrs. lost by detentions	Detentions: No.	Reason	VOYAGE 3 Hours: Total at Sea	Hours: Detention	% Sea hrs. lost by detentions	Detentions: No.	Reason
Sawokla	1123.07	3.87	.35	1	Cooling system	1757.38	15.54	.88	4	Cooling system	2206.7	24.34	1.10	5	Silencer Cooling system
City of Rayville	2212.62	1.83	.08	2	Water in oil Exhaust pipe & silencer	2019.03	36.8	1.68	2	Piston lub. oil line Broken piston skirt					
City of Dalhart	2061.67	11.99	.58	3	Cooling system Steering gear	2119.17	5.68	.27	3	Water service Cooling system Starting valve					
Yomachichi	2281.33	6.70	.29	2	Cooling system	1069.77	0	0	0		2582.17	51.35	1.99	4	Piston rods Cooling system
Tampa	721.92	0	0	0											Water in oil
Unicoi	1171.85	2.08	.18	4	Cooling system	2448.53	58.44	2.38	7	Cooling system Air compressor Piston rods	1923.25	8.89	.46	4	Starting valve Cooling system
Seminole	2362.93	21.98	.93	4	Steering gear Fuel valves Silencer										
Wilscox	1060.15	.2	.02	1	Relief valves	2319.45	6.81	.29	4	Air cooler Fuel valve Exhaust valve	2677.02	60.85	2.32	6	Dirty fuel Lub. oil piping
West Honaker	823.33	7.37	.90	1	Steering gear										Crank pin Exhaust valve
Crown City	2356.50	2.12	.09	3	Steering gear Crosshead bolt Drain line	2113.28	11.06	.52	3	Fuel injection valves Independent compressor unit	2704.67	16.80	.62	6	Fuel injection valve Exhaust valve
West Cusseta	1096.48	13.39	1.21	2	Cooling system	2457.82	13.98	.57	3	Fuel injection valve Lub. oil system	2532.62	3.83	.15	1	Fuel injection valve
West Grama	1423.0	38.47	2.70	4	Piston rods Cooling system Fuel pump Steering gear										

NOTE:—With exception of M. S. *Tampa* and M. S. *Unicoi* no port detentions have been caused by Diesel-conversion casualties. In the case of these two vessels detention in foreign ports was necessary awaiting arrival of redesigned piston rods.

Table 2.—Wage Schedules

	Motorship		Steamship: Hand-fired Coal		Steamship: Oil	
	No.	Per Month	No.	Per Month	No.	Per Month
Chief Engineer	1	$285.00	1	$260.00	1	$260.00
1st Asst. Engineer	1	195.00	1	185.00	1	185.00
2nd Asst. Engineer	1	175.00	1	165.00	1	165.00
3rd Asst. Engineer	1	155.00	1	150.00	1	150.00
4th Asst. Engineer	1	135.00				
Electrician	1	170.00				
Day Man	1	72.50				
Oilers	3	217.50	3	217.50	3	217.50
Wipers	2	115.00			2	115.00
Firemen	—	———	9	607.50	3	195.00
Coal Passers	—	———	3	180.00		
Watertenders	—	———	3*	217.50	3*	217.50
Total	12	$1520.00	22	$1982.50	15	$1505.00

* Three watertenders carried if vessel has watertube boiler or more than three Scotch boilers.

$1,982.50, as shown in the table. In the case of the oil burners, about 50 percent of the vessels are fitted with a similar type boiler, and in their case the total wage bill is $1,287.50 instead of $1,505.00 as shown.

The fourth engineer is carried on the motorship only for the purpose of training, in order to create a greater number of available engineers for use on motor-driven vessels.

Fuel Performance at Sea

The actual fuel performance at sea for the voyages of the vessels has been plotted shown in Fig. 1, which is a chart having observed speed in knots as the abscissa and actual pounds of fuel per observed mile as the ordinate. In view of the difference in speed, which varies from 9.38 knots up to 12.5 knots, and also as there is a difference in draft for the various voyages, Table 3 has been drawn up in order that a more favorable basis for comparison might be had, the fuel consumption figures being converted to a common displacement of 10,000 tons and further converted to a common observed speed of 11 knots, which is the average speed of the twelve vessels.

To effect this conversion, E. A. Stevens' modification of the Admiralty formula, as given in the 21st Proceedings of the Society of Naval Architects and Marine Engineers, has been used. That is:

$$\text{Horsepower} = \frac{\text{Displacement} \times \text{observed speed}^3}{C \times \sqrt{\text{length of vessel}}}$$

the constant C being obtained from curves showing its value for varying displacements.

The test data for the various engines show a straight-line relationship between total fuel and horsepower for the varying horsepowers within the range covered in this computation. It is therefore possible to compute the fuel consumption for the different conditions, as it will be approximately directly proportional to the corresponding horsepower.

The result is a total wherein the fuel consumptions are shown with the variations of displacement and speed eliminated. The total of the miles covered and the length of operating period of each of these vessels have been of sufficient magnitude so that the effect of such variables as current and weather is greatly minimized.

Fuel Performance in Port

It is in port service that the Diesel engine has an unquestionable advantage over the steam-driven cargo vessel, as stand-by losses are practically eliminated. The actual performance in port of eleven of the vessels is shown in Fig. 2. The performance of the *Wilscox* is not included on this chart, as the chart was prepared be-

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Table 3.—Fuel Performance

Motorship	Total miles	Actual av. obs. speed	Average displacement	Actual av. barrels per 24 hrs.	Barrels per 24 hours at 10000 tons displacement & 11 knots	Actual average lb. per mile	Lb. per mile at 10000 tons displacement & 11 knots	Type of Engine	
Sawokla	60,035	11.90	9515	99.34	81.5	108.6	96.4	Busch-Sulzer	2 cycle—S.A.—6 cylinders 3000 S.H.P. at 90 r.p.m.
City of Rayville.	48,273	11.46	9265	95.10	88.2	108.1	104.3	Busch-Sulzer	2 cycle—S.A.—6 cylinders 3000 S.H.P. at 90 r.p.m.
City of Dalhart.	49,242	11.83	9240	98.98	83.4	108.9	98.6	Busch-Sulzer	2 cycle—S.A.—6 cylinders 3000 S.H.P. at 90 r.p.m.
Yomachichi	26,743	11.76	10575	107.17	84.7	118.6	100.1	Busch-Sulzer	2 cycle—S.A.—6 cylinders 3000 S.H.P. at 90 r.p.m.
Tampa	46,606	10.79	9400	96.38	106.7	116.2	126.1	Worthington	2 cycle—D.A.—4 cylinders 2900 S.H.P. at 95 r.p.m.
Unicoi	57,818	10.60	8925	90.14	109.8	110.7	129.8	Worthington	2 cycle—D.A.—4 cylinders 2900 S.H.P. at 95 r.p.m.
Seminole	28,107	12.02	8360	123.27	107.8	133.5	127.4	M. A. N.	2 cycle—D.A.—4 cylinders 3680 S.H.P. at 115 r.p.m.
Wilscox	13,097	12.49	8077	114.63	93.2	119.4	110.2	M. A. N.	2 cycle—D.A.—4 cylinders 3680 S.H.P. at 115 r.p.m.
West Honaker...	60,580	10.55	8640	85.63	106.3	105.7	125.6	McIntosh & Seymour	4 cycle—S.A.—6 cylinders 2700 S.H.P. at 95 r.p.m.
Crown City.....	48,383	10.91	9630	92.77	97.4	110.6	105.1	McIntosh & Seymour	4 cycle—S.A.—6 cylinders 2700 S.H.P. at 95 r.p.m.
West Cusseta...	73,416	10.82	9485	86.59	94.1	104.1	111.2	McIntosh & Seymour	4 cycle—S.A.—6 cylinders 2700 S.H.P. at 95 r.p.m.
West Grama....	12,982	9.38	8880	59.99	105.1	83.3	124.3	McIntosh & Seymour	4 cycle—D.A.—4 cylinders 2700 S.H.P. at 95 r.p.m.

fore the completion of her initial voyage. It is, however, practically identical with that of the *Seminole*. It will be noted from Fig. 2 that the daily port consumption varies from the maximum of 7.1 to a minimum of 3.96 barrels per day. This variance is due in large part to the amount and type of cargo handled and is also greatly affected by the degree of economy in the use of auxiliaries, lighting, etc., exercised by the operating personnel of the vessel.

Lubricating and Cylinder Oil

Just as the Diesel has a decided advantage over the steam-driven cargo vessel in port performance, so has it a disadvantage in the use of lubricating and cylinder oil. This is one of the phases which must receive special attention by the operators of Diesel vessels. Fig. 3 gives the average performance for the various vessels during the period of operation covered by this paper. The lubricating oil per day is shown in solid block column while the cylinder oil is shown in cross-hatch, the two being graphically added so that the total length of column represents the total amount of lubricating and cylinder oil used for twenty-four hours at sea. Unfortunately, this chart does not permit arrival at definite conclusions, as there has been introduced a variable of various grades of oil and as in all initial installations the degree of caution exercised by the operating personnel also has a marked influence on these values. It is felt that, while they are indicative of what may be expected, it will be necessary to cover a much longer term of operation before it will be possible to determine conclusive values.

At the time of writing this paper, the twelve vessels of the initial phase of the Shipping Board's Diesel conversion program had traveled a total distance of 545,852 miles, for which we have recorded data. Although mechanical difficulties have been experienced, as cited in Table I, they are such as would normally be expected in an extensive program of this nature, purely pioneering and experimental to a certain extent. The difficulties that have been experienced are not insurmountable, and, although it is reasonable to expect that we shall experience more in the future, the success that has attended their performance to date has clearly demonstrated that American manufacturers can build a satisfactory and reliable marine Diesel engine in the larger sizes suitable for ocean-going vessels.

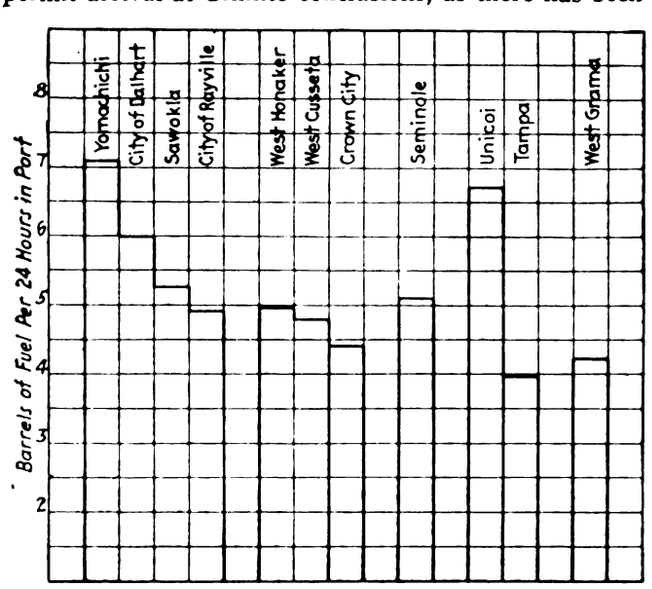

Fig. 2.—Port fuel consumption of Diesel converted vessels

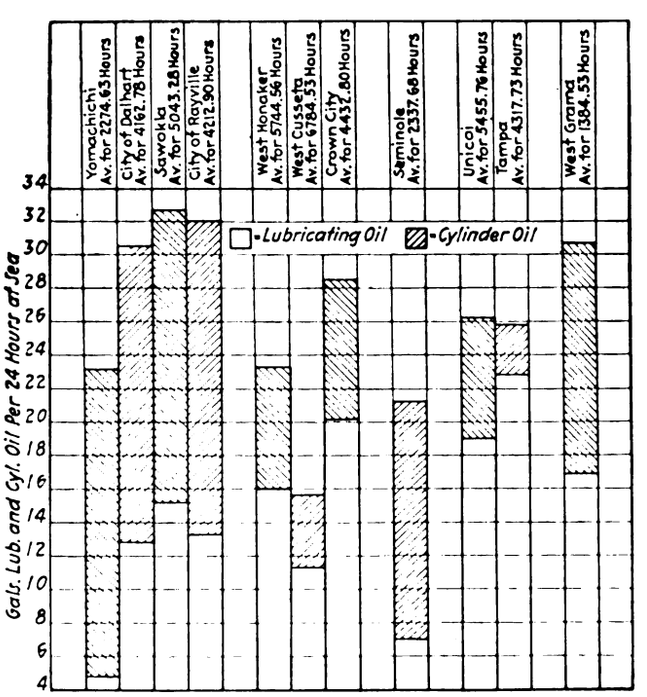
Gal. Lub. and Cyl. Oil Per 24 Hours at Sea
Yomachichi Av. for 2274.63 Hours
City of Dalhart Av. for 4162.78 Hours
Sawokla Av. for 5043.28 Hours
City of Rayville Av. for 4212.90 Hours
West Honaker Av. for 5744.56 Hours
West Cusseta Av. for 6784.53 Hours
Crown City Av. for 4432.80 Hours
Seminole Av. for 2337.68 Hours
Unicoi Av. for 5455.76 Hours
Tampa Av. for 4317.73 Hours
West Grama Av. for 1384.53 Hours
Lubricating Oil
Cylinder Oil

Fig. 3.—Consumption of lubricating and cylinder oil at sea

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Tests of an Anchor Windlass

By Commander Q. B. Newman, U. S. C. G.

THE power required to heave in an anchor is subject to a greater number of disturbing influences than almost anything else on the ship. About the only dependable figures in the problem are the weight of an anchor and the weight of the greatest up and down scope of chain. Variable and uncertain factors are gear and journal friction hawse-pipe friction, and the effects of wind and tide. Consequently, a back ground of experience is likely to be of more value than a slide rule in calculating the power to be installed.

On the five Coast Guard cutters now building at the Fore River plant of the Bethlehem Shipbuilding Corporation, Ltd., it was decided to install motor-driven anchor windlasses, with a train of spur gears to give a hoisting speed of about 6 fathoms per minute. Such information as was available indicated that a 30-horse-power motor should be sufficient, and that size was installed. So far as known these are the only anchor windlasses in the world which are driven by alternating-current motors, and their performance was naturally watched with much interest.

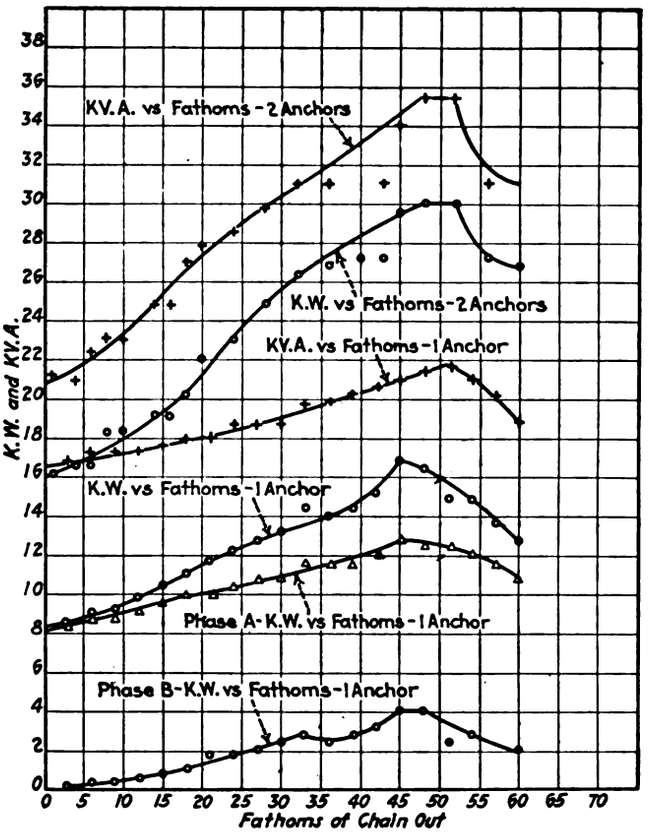
KV.A. vs Fathoms - 2 Anchors
K.W. vs Fathoms - 2 Anchors
KV.A. vs Fathoms - 1 Anchor
K.W. vs Fathoms - 1 Anchor
Phase A - K.W. vs Fathoms - 1 Anchor
Phase B - K.W. vs Fathoms - 1 Anchor
K.W. and KV.A.
Fathoms of Chain Out

Fig. 1.—Results of heaving-in one and two anchors with 60 fathoms of chain paid out

The motor is a three-phase wound-rotor induction motor with external secondary resistances sufficient for speed reduction in ten steps to 50 percent of rated full speed. The motor is watertight and is mounted on the windlass bedplate. The controls, which are extremely simple, are installed below deck, and connected by a

TABLE 1.—TWO ANCHORS

Chain Out, Fms. Volts	Ammeter No. 1	Amperes = Reading × 20	Ammeter No. 2	Amperes = Reading × 20	K.V.A.	Wattmeter No. 1	K.W. Phase A = Reading × .040	Wattmeter No. 2	K.W. Phase B = Reading × .040	K.W.
60	4.4	88	4.4	88	31.0	450	18.0			26.8
	4.4	88	4.4	88	31.0	460	18.4			27.2
	5.0	100			35.4	500	20.0	250	10.0	30.0
	5.0	100	5.0	100	35.4	500	20.0			30.0
	4.8	96	4.8	96	34.0	500	20.0	240	9.6	29.6
	4.4	88	4.4	88	31.0	450	18.0	230	9.2	27.2
40	4.8	96	4.8	96	34.0	450	18.0	230	9.2	27.2
204	4.4	88	4.4	88	31.0	450	18.0	220	8.8	26.8
	4.4	88	4.6	92	31.0	460	18.4	200	8.0	26.4
	4.0	80	4.4	88	29.8	450	18.0	170	6.8	24.8
	4.0	80	4.0	80	28.5	425	17.0	150	6.0	23.0
20	3.8	76	4.0	80	27.8	400	16.0	150	6.0	22.0
. 205	3.6	72	4.0	80	27.0	375	15.0	130	5.2	20.2
	3.3	66	3.4	68	24.8	350	14.0	130	5.2	19.2
	3.3	66	3.4	64	24.8	350	14.0	130	5.2	19.2
207	3.1	62	3.2	64	22.7	325	13.0			
	3.2	64	3.2	64	23.1	350	14.0	110	4.4	18.4
	3.2	64	3.2	64	23.1	350	14.0	110	4.4	18.4
	3.1	62	3.1	62	22.4	325	13.0	90	3.6	16.6
	2.9	58	2.9	58	21.0	325	13.0	90	3.6	16.6
	2.9	58	3.0	60	21.3	325	13.0	80	3.2	16.2
	2.6	52	2.8	56	19.4	275	11.0	70	2.8	13.8
208	2.5	50	2.8	56	19.4	275	11.0	60	2.4	13.4
	2.8	56	2.8	56	20.2	275	11.0	70	2.8	13.8
0	2.7	54	2.9	58	20.2	300	12.0	70	2.8	14.8

TABLE 2

Chain Out, Fms.	No. of Anchors	Weight of Useful Load, Lbs.	Time to Hoist 15 Fms., Min.-Sec.	Hoisting Speed, Ft. per Min.	Useful Work, Ft. Lbs. per Min.	Useful H.P.	Input to Motor, K.W.	Load Factor, percent	Power Factor, percent	Motor Efficiency, percent	Motor Output, H.P.	Hawse Pipe and Gear Efficiency
60	2			34.2			26.7	105	86.5	88.0	31.6	
55	2			34.2			27.6	109	85.5	87.9	32.5	
50	2			34.2			30.0	118	85.6	87.0	35.1	
47	2	21,000		34.2	718,000	21.7	29.9	118	86.3	87.0	34.9	62.3
45	2	20,460	2:38	34.2	700,000	21.2	29.6	116	85.6	87.0	34.5	61.5
40	2	18,920		33.6	680,000	20.8	28.3	112	85.2	87.8	33.1	62.8
35	2	17,480		33.6	587,000	17.8	27.2	107	86.1	88.0	32.1	55.5
30	2	15,960	2:41	33.6	537,000	16.3	25.5	101	84.4	88.2	30.2	54.0
25	2	14,440		34.2	494,000	15.0	23.7	90	81.9	88.3	28.0	53.8
20	2	12,900		34.2	442,000	13.4	21.3	84	79.8	88.4	25.2	52.3
15	2	11,440	2:38	34.2	381,000	11.5	19.3	76	78.0	88.4	22.9	50.3
10	2	9,900		34.2	338,000	10.2	17.9	71	77.2	88.0	21.2	48.2
5	2	8,400		34.2	287,000	8.7	16.8	66	77.0	88.0	19.8	43.8
0	2	8,000		34.2	273,000	8.3	16.0	63	77.0	87.7	18.8	44.2
60	1			35.3			12.6	49	67.0	86.8	14.7	
55	1			35.3			14.5	57	70.3	87.0	16.9	
50	1			35.3			16.0	63	73.3	87.7	18.8	
47	1	10,500		35.3	371,000	11.2	16.6	65	75.0	87.8	19.5	57.6
45	1	10,230	2:33	35.3	361,000	10.9	16.8	66	75.0	87.8	19.7	55.6
40	1	9,460		34.4	325,000	9.8	14.8	58	73.3	87.0	17.3	56.6
35	1	8,740		34.4	300,000	9.1	13.9	55	70.3	87.0	16.2	56.2
30	1	7,980	2:37	34.4	274,000	8.3	13.2	52	69.5	86.8	15.3	54.4
25	1	7,220		35.0	256,000	7.8	12.4	49	67.0	86.8	14.3	54.4
20	1	6,450		35.0	226,000	6.9	11.5	45	64.3	86.3	13.3	52.0
15	1	5,720	2:34	35.0	200,000	6.1	10.5	41	58.8	86.0	12.1	50.5
10	1	4,950		35.0	173,500	5.3	9.5	37	55.0	85.0	10.8	49.0
5	1	4,200		35.0	147,000	4.5	8.8	35	52.3	84.5	10.0	45.0
0	1	4,000		35.0	140,000	4.2	8.4	33	52.0	83.5	9.4	44.7

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shaft to an operating hand wheel at the windlass. Current for the motor brake is obtained from a disk rectifier.

An alternating-current motor was used for a combination of reasons, among which are the following: It is more rugged than a direct-current motor and requires less attention and care; it has no commutator; it has excellent starting qualities; it can be grievously overloaded and even stalled without injury; and, finally,

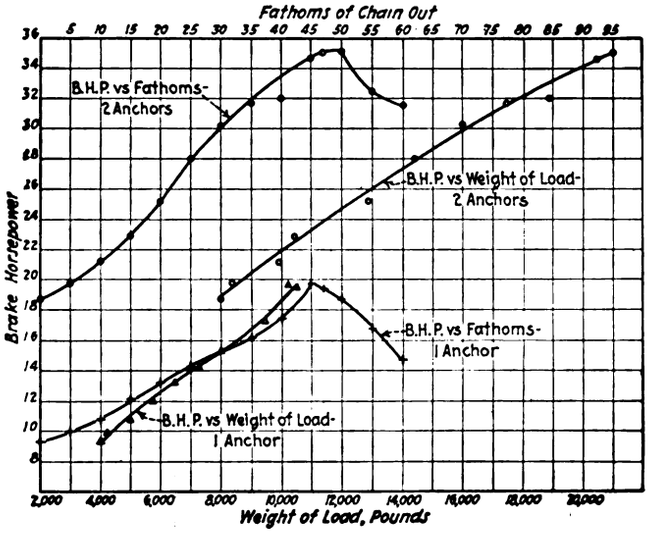
Fathoms of Chain Out
B.H.P. vs Fathoms-2 Anchors
B.H.P. vs Weight of Load-2 Anchors
B.H.P. vs Fathoms-1 Anchor
B.H.P. vs Weight of Load-1 Anchor
Brake Horsepower
Weight of Load, Pounds

Fig. 2.—Motor output on both tests for weight of load and for scope of chain out

there was a surplus of alternating current available for driving it.

In measuring the power in a three-phase circuit two methods may be employed; the current in one lead may be measured and the voltage between two leads. Then, the kilovoltamperes is K.V.A. = volts x amperes x $\sqrt{3}$. To get the power in kilowatts the power factor must be known; K.W. = volts x amperes x $\sqrt{3}$ x P.F.

The other method is by the use of two single-phase wattmeters. One meter takes the current in lead No.

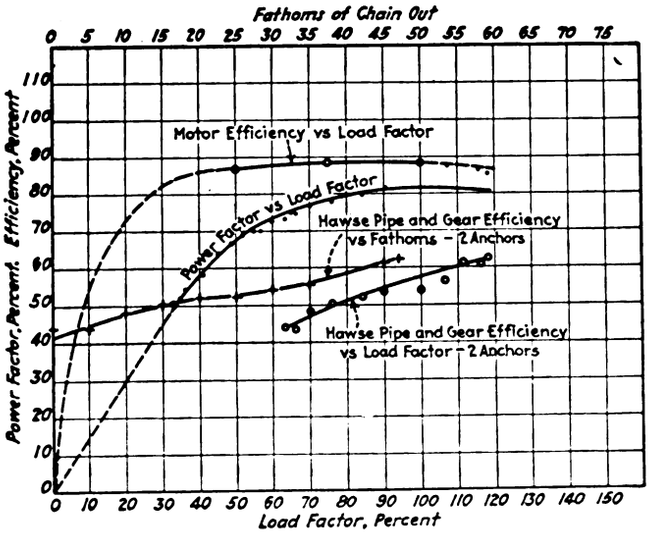
Fathoms of Chain Out
Motor Efficiency vs Load Factor
Power Factor vs Load Factor
Hawse Pipe and Gear Efficiency vs Fathoms - 2 Anchors
Hawse Pipe and Gear Efficiency vs Load Factor - 2 Anchors
Power Factor, Percent. Efficiency, Percent
Load Factor, Percent

Fig. 3.—Motor efficiency as determined on factory test

1 and the voltage between leads 1 and 3. The other takes the current in lead No. 2 and the voltage between leads 2 and 3. The sum of the two readings is the total power. It will be observed in the tabulations and curves that the power factor decreases with the decrease

TABLE 3.—ONE ANCHOR

Chain Out, Fms.	Volts	Ammeter No. 1	Amperes = Reading × 20	Ammeter No. 2	Amperes = Reading × 20	K.V.A.	Wattmeter No. 1	K.W. Phase A = Reading × .040	Wattmeter No. 2	K.W. Phase B = Reading × .040	K.W.
	209	2.5	50	2.7	54	18.8	260	10.8	50	2.0	12.8
		2.8	56	2.8	56	20.2	290	11.6	50	2.0	13.6
		2.9	58	2.9	58	21.0	300	12.0	70	2.8	14.8
		3.1	62	2.9	58	21.7	310	12.4	60	2.4	14.8
		3.0	60	2.9	58	21.4	310	12.4	100	4.0	16.4
		2.8	56	3.0	60	21.0	320	12.8	100	4.0	16.8
		2.8	56	2.9	58	20.6	300	12.0	80	3.2	15.2
		2.8	56	2.8	56	20.2	290	11.6	70	2.8	14.4
		2.8	56	2.7	54	19.9	290	11.6	60	2.4	14.0
	208	2.8	56	2.7	54	19.8	290	11.6	70	2.8	14.4
		2.6	52	2.6	52	18.7	270	10.8	60	2.4	13.2
		2.6	52	2.6	52	18.7	270	10.8	50	2.0	12.8
		2.6	52	2.6	52	18.7	260	10.4	45	1.8	12.2
		2.5	50	2.5	50	18.0	250	10.0	45	1.8	11.8
		2.5	50	2.5	50	18.0	250	10.0	25	1.0	11.0
		2.5	50	2.4	48	17.6	240	9.6	20	.8	10.4
		2.4	48	2.4	48	17.3	230	9.2	15	.6	9.8
		2.4	48	2.4	48	17.3	220	8.8	10	.4	9.2
		2.4	48	2.4	48	17.3	220	8.8	10	.4	9.2
		2.4	48	2.3	46	16.9	210	8.4	5	.2	8.6

in load; and that, as the power factor decreases, the difference between the two wattmeters becomes greater. If the power factor should drop to 50 percent, one meter would show the total load and the other would show 0.

Both methods were used on the tests described herein. The equipment consisted of two wattmeters, two ammeters and one voltmeter.

The tests were made on the *Pontchartrain* off the port of Boston in 47 fathoms of water. The weather was good and the effects of wind and current were negligible.

The anchors are stockless and weigh 4000 pounds each. The chain is 1¾-inch stud link, cast steel, and 15 fathoms weigh 2590 pounds. The weight of cast steel in sea water is taken as 426 pounds per cubic foot, or 87.2 percent of its weight in air.

Two anchors and 60 fathoms of chain on each were paid out for the first test. The results of heaving-in are given in Tables 1 and 2 and Fig. 1. One anchor was then let go and 60 fathoms of chain paid out. Heaving-in is shown in Tables 2 and 3 and Fig 1. The difference in wattmeter readings above referred to is strikingly shown on this test.

Fig. 2 shows the motor output on both tests for weight of load in pounds and also for scope of chain out. It should be remarked that the power required is greater for a given load when coming in through two hawse pipes than through one. For example, if the useful load is 10,000 pounds, 21.9 brake horsepower is required with two chains; but only 18.6 for one chain.

Fig. 3 shows the motor efficiency as determined on factory test; a power-factor curve derived from the ratio of K.W. to K.V.A. in Fig. 1; and the combined efficiency of gear train and hawse pipes from Tables 2 and 3.

INTERNATIONAL CODE OF SEA LAWS.—An international code of sea laws designed to promote safety at sea will be submitted by an American delegation to a conference of representatives of the maritime powers of the world to be held at London some time after April, 1929, for a revision of the convention of 1924 for the safety of life at sea, it has been announced by the Department of State. Legislation is pending in Congress to provide for American participation in the conference and President Coolidge has requested an appropriation of $100,000 for the purpose. It is stated that among the subjects to be dealt with will be ship construction, ice patrol, safety devices, wireless and fire extinguishers.

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Naval Architects Discuss Propulsion Problems at Annual Meeting

Performance records of converted Shipping Board vessels — Review of pulverized-fuel developments — Applications of turbine-electric drive

RENEWED activity in the shipyards of the country, as a result of the Jones-White legislation and the prospective naval program, was the keynote of the thirty-sixth general meeting of the Society of Naval Architects and Marine Engineers, held in the auditorium of the Engineering Societies Building, New York city, November 15 and 16. Homer L. Ferguson, president of the society, was in the chair throughout the meeting.

The first day's meeting was devoted to routine business and the discussion of papers of a general character. The morning session on Friday dealt with combustion-engineering problems, while at the afternoon session various phases of turbine-electric drive for different types of vessels were discussed.

The report of the secretary-treasurer, D. H. Cox, was presented to the society as the first order of business. During the year there have been 25 deaths and 26 resignations from the membership roll. The total membership in all classes as of October 31, 1928, is 1376 as against 1344 a year ago. As a result of the drive for new members during the year, 115 applications in various classes were received and acted upon at this time by the meeting.

According to the financial statement, the total assets of the society as of October 31, 1928, amounted to $119,212.46, of which $89,898.81 constitutes the endowment fund. The endowment fund has grown to such proportions that the income alone amounts to about $6000 a year. It has been suggested that medals or cash prizes be awarded to the authors of the best papers presented before the society, the fund being utilized for this purpose. A committee has been appointed to study the matter and make recommendations at a later meeting of the society.

Election of Officers

The following officers were elected to fill existing vacancies:

Honorary vice-president: Francis L. Du Bosque.
Vice-Presidents (term expiring December 31, 1931): J. Howland Gardner, Richard M. Watt, Charles P. Wetherbee, Herbert C. Sadler.
Vice-President (term expiring December 31, 1929): John Halligan, Jr., vice F. L. Du Bosque.
Council members, representing members (term expiring December 31, 1931): Hugo P. Frear, Theodore E. Ferris, Frank M. Lewis, William W. Smith, Elmer A. Sperry, William L. R. Emmet.
Council members, representing members (term expiring December 31, 1929): Henry Penton, vice H. C. Sadler, John F. Metten, vice H. P. Norton resigned.
Council member, representing members (term expiring December 31, 1930): William S. Newell, vice John Halligan, Jr.
Council members, representing associates (term expiring December 31, 1931): Paul H. Harwood, George D. Ali, Alfred G. Smith.
Executive Commitee: Homer L. Ferguson, Washington L. Capps, Walter M. McFarland, Francis L. Du Bosque, Joseph W. Powell, J. Howland Gardner, Charles A. McAllister, Morris Douw Ferris.
Committee on Papers: Francis L. Du Bosque, J. Howland Gardner, Herbert L. Aldrich, William W. Smith.
Secretary-Treasurer: Daniel H. Cox.
Assistant Secretary-Treasurer: Thomas J. Kain.

As is customary at the opening session, the president at this time reviewed the shipbuilding prospects for the coming year.

The President's Address

The year drawing to a close has been momentous in the shipbuilding industry. Accomplishments have been substantial, but it is the dawning of a new era in shipbuilding in America that sets this year apart from the lean years of the past.

Outstanding among the events which have marked this year is the passage of the Jones-White Act. This legislation with its favorable loan provisions and its mail subventions is too well known among the membership of this society to be discussed at length at this time. Years of effort on the part of those who have seen the vital need of this legislation have at last borne fruit in an almost nation-wide realization of our merchant marine as an essential factor in our foreign trade and national defense.

It is especially gratifying to us, as shipbuilders and members of the professions of naval architecture and marine engineering, that the incoming chief executive of the nation has given this policy his hearty endorsement. In his speech at Boston a month ago Mr. Hoover stated: "The hope of a substantial merchant marine lies ultimately in the new character of overseas shipping, in the energy and initiative of our citizens with assistance and co-operation of the Government. That assistance and co-operation are now being given and must be continued."

Present Outlook for New Work

Although there have been several notable additions to the American merchant marine during the year, the volume of work in the shipyards has been pitifully small. The outlook, however, under the Jones-White Act is encouraging. Many important mail contracts have been awarded and the Shipping Board has received a number of applications for loans with which to finance new construction. Plans and specifications for twenty new vessels have already been completed and designs for twenty-two more are in various stages of development. These vessels are generally of the passenger and cargo type, some of them of considerable size, and all thoroughly modern in design. In addition to the new construction contemplated, reconditioning and modernizing of several large vessels is under consideration and work is actively starting on a continuation of the Shipping Board conversion program, contracts having recently been placed with shipbuilders for converting eight steamers of 9300 tons deadweight into up-to-date motorships.

In reviewing the closing year, it is necessary to record an unfortunate event, not only for shipbuilders but for

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the nation as a whole, in the failure of the Senate to act upon the bill embodying the administration naval-building program. After our act of immolation in 1921 when new American fighting ships were scrapped and old ones retained, it became the imperative duty of those charged with the nation's defense to maintain our reduced Navy at the peak of efficiency, and the failure to provide the units necessary to round out the fleet into an effective and co-ordinated fighting machine is nothing less than blind and dangerous folly. Paper ships have never prevented war nor repelled an enemy.

We are standing today at the dawn of a new era in overseas transportation and it is not surprising that American ship owners and builders should endeavor to be in the forefront when new standards of speed are being projected both in passenger travel and transportation of goods. Spurred on by keen competition, shipbuilders abroad have been building cargo ships with a service speed of 14 to 15 knots, made possible largely through efficient propelling machinery. American owners, with government co-operation, will not fall behind and the day is not far distant when the "express cargo liner" will have its place in the American merchant marine. Mr. Hoover has caught the vision of the present age in pointing out the need for "regular, ferry-like service of large cargo-liner ships."

The spectacular and ambitious proposal to step-up the speed of travel in the North Atlantic seven knots, or more, by the building of a great fleet of four-day liners has met with keen interest on the part of both the public and marine engineers and naval architects. Despite the unfavorable report of the Shipping Board, the economic and engineering phases of this giant undertaking are being carefully worked out by experts and we may expect further developments in this proposition.

Steam Power Developments

The continued progress of the marine Diesel engine with its low fuel consumption has stirred designers and manufacturers of the various units of steam propulsion to new efforts to improve the economy of their machinery. Profiting by the experience in central power stations ashore, these efforts have been directed largely toward making higher steam pressures and temperatures practicable on shipboard. One large American vessel has entered service during the year with a steam pressure of 350 pounds and 200 degrees Fahrenheit superheat, and another larger vessel will be completed this month with boilers generating steam at 300 pounds and 200 degrees Fahrenheit superheat, while practically all of the large vessels now projected with steam machinery will employ pressures and temperatures in this range or higher.

Electric Drive

During the year, electric drive has further demonstrated its advantages in the field of large, fast passenger and freight ships. The successful operation of the Panama-Pacific steamship *California,* to be followed next month by the steamship *Virginia,* has led the International Mercantile Marine Company to install this same type of machinery in its third ship of this class now under construction. Electric propelling machinery will be fitted also on a large passenger liner to run between New York and the West Coast of South America, the contract for which has recently been placed.

Modernizing Program

The modernization of existing tonnage has also been a feature of 1928. Several large ships have re-entered service with modernized passenger accommodations, work on others is under way, and similar work is contemplated on a number of others, including, perhaps, the ex-German liners now known as the *Mount Vernon* and *Monticello.*

Outstanding in this work of modernization is, of course, the Shipping Board's Diesel conversion program, the continuation of which is now going ahead on eight vessels.

Pulverized-Coal Installations

In line with the Shipping Board's policy which has resulted in the valuable experience gained in the construction and operation of these motorships, and in the use of pulverized fuel on the steamship *Mercer,* other experiments might be made by the Board with great profit to American shipbuilders and shipowners in high-pressure steam machinery and in combination reciprocating-engine and low-pressure turbine installations, which latter type of propulsion especially seems to offer further possibilities in the utilization of some of the government's idle fleet.

There has been a steadily growing tendency in recent years, especially marked in 1928, during which plans have been formulated for the construction of so many first-class ships, to improve upon past standards, not only along structural and engineering lines, but to an equally great extent in matters which have to do with safety of life, handling, protection and preservation of cargo, aids to navigation, and the comfort, service and entertainment of passengers.

Cost Reduction

In line with the Shipping Board's policy which has builders have been enabled to make, such improvement in the conditions of travel at sea has not, of course, been brought about without an increase in the cost of building the ships. The owner, who expects to build a first-class ship today at the same price as was paid for previous ships even five years ago, is either doomed to disappointment, or, if his expectation is realized, the ship will contain not a few items for which the shipyard has received no pay at all. One of the things which affects the cost disproportionately is the fact that the owner's naval architect has a distinct tendency to provide a design which is more elaborate than the particular service demands, or which fails to take advantage of the cheapest way of accomplishing the desired result, or which is so described that some of the estimators are left in doubt as to what the cost is going to be. Moreover, cost is materially affected by volume, and unless the shipyards are kept full of work, the cost of any particular vessel is higher than it would otherwise be, even though this increase in cost, due to excessive competition, may not show in the price. The excessive competition to which I refer is not merely that between commercial shipyards, but includes the Navy yards, which, unfortunately, according to many in Congress, must be kept busy building ships even though the shipyards are put out of business due to lack of work.

Developments in Shipbuilding

Shipbuilding along industrial lines has kept pace with the developments in design and engineering. Chief among the newer methods which have helped the builder, and to the development of which the year 1928 has contributed substantially, is electric-arc welding. Impetus has been given to this process by its extensive use largely as a means of saving weight without sacrifice of strength, on the scout cruisers now under con-

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struction. Completely welded barges are now being built, welded fittings as well as structural members are extensively used.

Another line along which a start at least has been made and which seems to offer inviting possibilities in the way of improving the quality of work aboard ship, with a reduction in both operation and construction costs, is that of finishing wood and metal surfaces. Lacquers have found an enormous field in the past five years in the automobile industry and aluminum paint is being tried extensively in factory buildings and on steel work. Its use on the scout cruisers under conditions at sea will furnish shipbuilders and shipowners valuable information. The successful use of these new processes in work ashore will certainly be followed shortly by their general application to the marine field.

Among the developments of the year in the shipbuilding industry has been the wider application of modern management methods. Two factors alone have saved the shipyards thousands of dollars during the past year; one of these has been an intensive campaign to eliminate waste, a war waged as earnestly by workmen as by supervisors; and the other a safety campaign which has reduced accidents to a new low level. This is too broad and tempting a field to venture far into at this time, but before bringing this review of American shipbuilding in 1928 to a close, I should like at least to name for you the management factors which we in our plant have found to offer great possibilities in reducing the costs of building ships, and these are:

Complete control of materials
Budgeting of shop expense and direct labor
An incentive system for every worker
Planning and scheduling

Lower costs to the shipbuilder mean lower prices to the shipowner; price is the serious handicap under which shipbuilding in the United States suffers, and to the lowering of which all naval architects and marine engineers should bend their best energies.

Application of Welding to Ship Construction

By James W. Owens

An abstract of this paper is published on page 651 of this issue.

Discussion

E. H. EWERTZ, as a member of the American Welding Society and a past president of that body, congratulated the society on the development of the use of welding in ship construction. The principal objection that has in the past been raised against the use of the process has been the human element, but the same condition holds true in the case of building a riveted ship. From the drawing room to the completed structure, the judgment of mechanics is depended upon in the construction of a vessel. Once the rivets have been driven, it is impossible to know what strains have been set up in the adjacent metal. Experience is largely depended upon for a knowledge of conditions in the metal. If the welded design is correct, if high temperatures are provided for and if the machinery used is suitable, the final results with welding should be satisfactory. It is a simple matter to train men to put the necessary amount of metal into the weld. With proper allowances and margins of safety the same satisfactory results should be obtained as in the case of the rivet.

Some of the advantages of the process are savings in weight and labor which are accomplished by a less number of parts, placed in a simpler way. The material is used to its full value for there are no holes in plates to be used for welding, which is the case with rivets.

This method of joining metals is finding wide application in Europe especially in ship construction, and unless the process is utilized here to help cut costs of production, the differential in price between here and abroad will probably grow worse.

A. M. CANDY outlined the work which the Westinghouse Electric & Manufacturing Company has been doing in recent years to promote the use of welding in all manner of structural work. The advantages of the process are that it provides more rigid and lighter construction, painting is easier because of smoother surfaces, beams can be made in effect continuous, the cost is in general less and joints may be partially assembled in the shop and completed in the field. Welded assemblies are at present being used to great advantage in replacing castings where a reduction in weight is obtained as well as a considerable saving in machining. A number of slides were presented to show the applications of the process being made by this company.

H. E. ROSSELL: In discussing the matter of weight the author states that savings as high as 71.4 percent may be made by welding instead of riveting. The basis of any such saving appeals to me as fundamentally unsound. It has been my experience that on structural work welding permits weight savings of 10 to 25 percent without sacrifice of strength. Often it is possible to effect even greater savings on plated structures such as oil or watertight bulkheads or tanks by taking advantage of the inherent superiority of welding in point of tightness and in point of rigidity.

In my opinion the author dismisses too lightly the question of fatigue resistance of welded joints. If welding is to be used on the joints of longitudinal strength members, the endurance limit of the deposited metal is of extreme importance. Moreover the effect on fatigue resistance of longitudinal strength members caused by lines of welding across these members should not be ignored.

I do not believe that the time is ripe for doing away with riveting in favor of welding on large or medium sized ships. I do believe, however, that welding is entitled to recognition as a satisfactory means of making strength joints in structural work, subject to its gradual introduction on integral parts rather than on entire structures.

J. F. LINCOLN: The automatic carbon welder is a comparatively recent development and the use of it for automatic work with the shielded arc is a development that was put on the market within the last few months. The inherent advantage of this type of equipment is the fact that the welding speed is enormously higher than is possible with any other arc process and with the shielded electrode weld metal can be obtained which is very much better than can be obtained with the usual metallic-electrode process. Welding speeds of two to twenty times that of hand or automatic metallic-electrode are obtainable and at the same time the weld metal will be homogeneous, free from slag and oxide, and of a flat and attractive finish.

The currents and sizes of electrodes mentioned by Mr. Owens should in all cases be materially increased for the best results. Electrode sizes should in general (certainly up to ¼ inch) follow directly with the thickness of metal welded, and certainly on one inch metal instead of using 5/32 inch electrode. Electrodes of at

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least $\frac{5}{16}$ inch to $\frac{3}{8}$ inch should be used with currents above 300 amperes.

Referring to single and multiple-operator machines, the latter is the same type machine exactly as was used by Benardos and Slavinoff more than forty years ago in their original experiments on arc welding. The single-operator machine is the later development, generating as it does the proper voltage and current for the work to be done rather than generating, as the multiple-operator machine does, a voltage three to four times as high which must be cut down by the stabilizing resistance to the proper voltage at the arc. I doubt very much if the use of the multiple-operator machine can be justified under any conditions if the economics of the situation are considered.

Mr. Owens also speaks of the warping of the welded plates, bringing out the point that carbon arc welding warps the plates more than metallic welding. This cannot be verified in actual practice. Since the heating of the plate is less, the tendency for warping will be very much less with the carbon electrode than with the metallic-electrode welding.

DAVID ARNOTT: In defining the probable third step towards improving hull construction as "the gradual elimination of the rivet itself by the welding of the component parts of the ship" emphasis should be placed on the word gradual, if only because of the fact that methods and procedure are so vitally important if reliable welds are to be obtained. It is not merely a question of allowable unit stresses in design or of obtaining complete fusion, but, as the author is careful to point out in discussing types of joints, the important consideration is the indeterminate residual stresses set up by the cooling of the weld metal.

It is undoubtedly true that a real saving in hull weight could be effected by the use of welding when it is remembered that our present rolled structural shapes have been evolved for use in riveted construction. Savings in weight, however, must not be effected at the expense of structural efficiency.

H. F. NORTON: The extension of the use of welding in ship construction seems to me to depend upon two principal elements; one the development of satisfactory assembly methods, which can only be done by the designer working with a shop man who is thoroughly familiar with previous assembly methods, and yet broadminded enough to be willing to consider and accept the possibility of breaking away completely from such previous methods and developing equivalent methods suitable for welding. The other element is, of course, the development of suitable welding details and the actual production of satisfactory welds.

C. W. BRYAN: The field of responsibility in welding may be divided into three parts:

1. *Design.* The owner who orders a manufactured product, and the manufacturer who guarantees it, must be protected by an adequate design. Too much stress cannot be laid upon the desirability of naval architects and engineers informing themselves on this subject, and it is obvious that the use of this very important and valuable process must be advanced principally through the interest of this group.

2. *Equipment.* Without adequate equipment, no welding work can be performed satisfactorily, but it appears at the present time as though the manufacturers of equipment were in advance of the demands and that no company need be reluctant to attempt welding work for fear of that feature.

3. *Personal Element.* The third influence in obtaining a good welding job is the welder himself. This is felt principally in manual welding work and to guarantee the owner and designer the quality of work which they expect, progressive shipbuilders are testing all members of their welding force intrusted with strength welds, according to methods suggested by Mr. Owens.

CAPTAIN H. C. DINGER, U. S. N., discussed a number of elements that are essential to the ultimate development of the welding process as applied to ship construction. These elements include a standard nomenclature and the development of standard symbols; the elimination of doubt raised by many in the form of the human element factor. Captain Dinger in his discussion, which is a complete review of the entire situation, dealt with the characteristics of welded structures and pointed out the requirements that must be met in fulfilling them.

ELIHU THOMSON: It is many years ago since I watched the joining of plates by riveting, and found the difficulty in exactly matching the holes to the rivet bodies so that the holes lined up correctly. I have witnessed the use of drift pins for forcing them to line where they did not exactly line, and it did seem to me that modern advance in the joining of metals should be found capable of getting the results without these somewhat rough methods. It is a gratification, therefore, to find in the paper of Mr. Owens so much that bears on the details of the kind of work to be accomplished by the various methods of welding and to find, also, that there is a very excellent beginning of application of these methods through actual construction of important ships.

Developments in Shipbuilding on the Great Lakes

By Albert W. Cross

An abstract of this paper will be published in an early issue.

Discussion

HENRY PENTON: Since the development of the type ship cannot be disassociated from that of the shore plant —in fact the two are interwoven—I have taken the liberty of offering some data which may help those unfamiliar with the trade to a better understanding of the factors underlying and controlling such development. Because, in such relatively short voyages, reduction of port time is all-important, much more so than the question of speed of ship, every effort has been bent in that direction. Thus, the shore plant has been steadily improved to economize the ship's time and the ship has been, coincidentally, modified to facilitate and take advantage of the utmost possibilities of the shore plant. As regards the ship, a design is aimed at, which assumes the highest rate of loading or unloading to be a sustained or standard performance. Mr. Penton then cited loading and unloading rates for ore, coal and grain, the three major bulk cargo types carried in Great Lakes vessels.

H. C. TOWLE called attention to some of the remarkable results obtained in the construction of Lake vessels with equipment which is comparatively simple in nature. Erection is carried on in Great Lakes yards at a much higher rate of speed than on the coast. During the last five years production costs have also been greatly reduced.

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WILLIAM BENNETT. It is a remarkable fact that, contrary to what one would expect from a glance at these comparatively long shallow vessels, the stresses in the homogeneously loaded conditions are very reasonable as compared with ocean-going vessels. This is due largely to the comparatively short steep waves encountered on the Great Lakes, as against the much longer waves frequently met on the Atlantic or Pacific.

Mr. Cross touches on the question of deflections in these vessels. He mentions one case in point in which the vessel hogged 16 inches in the light condition, although this hog decreased overnight by 5½ inches due to a change in temperature of about 15 degrees. From observations which I have made on these vessels it would appear that a change of about 35 degrees in temperature would be required for the quoted change in deflection. The maximum hog mentioned in the paper, namely 16 inches, evidently refers to a self-unloader. This amount of hog is not altogether unexpected, when we consider the length of these vessels and the heavy weights of the conveyor and machinery forward, usually about 500 or 600 tons, together with the increase in hog due to temperature differences. In fairness to the self-unloader, however, it should be remembered that although they have a heavier load than the ordinary freighter at the fore end in the light condition, this does not apply in the loaded condition, as the latter carries her load further forward.

Design of Airplane Carriers and Notes on the Saratoga and Lexington

By Rear Admiral G. H. Rock, (CC) U. S. N.

An abstract of this paper will be published in an early issue.

Discussion

PROFESSOR WILLIAM HOVGAARD: The design of airplane carriers is a subject to which considerable study has been given during recent years in the course of naval construction at the Massachusetts Institute of Technology. Various types of machinery plant have been considered and studied with special regard to the disposal of smoke or gases of combustion. High speed and hence high power is certainly desirable, but probably it will be necessary for the present to be satisfied with a speed substantially lower than that of cruisers and destroyers.

It seems that Diesel engines are the most suitable in view of the smoke problem. In order to obtain great powers with a Diesel-engine plant it may be worth considering the use of a great number of relatively small and light fast-running engines, each driving a generator directly and supplying current to the propelling motors. In a design now under consideration as a study at the Institute it is contemplated to use 16 engines of about 3000 rated horsepower each, giving a total of about 45,000 horsepower to be distributed on four propellers.

It is believed that the draft should be reduced as much as practicable with due regard to the required speed and sea-worthiness. When draft is reduced, length and beam can be increased on a given displacement and the flight deck made longer and broader, while at the same time more floor space is gained in the hold for installing the engines.

E. H. B. ANDERSON: The battle cruiser H. M. S. *Hood,* is equipped with the most powerful machinery plant, next to the *Lexington* and *Saratoga,* installed in any warship. This vessel was completed in 1920 and on trial made a speed of 32.07 knots with about 150,000 shaft horsepower and shaft revolutions per minute of 206; at maximum power the machinery developed 157,000 shaft horsepower. The propelling machinery consists of four independent sets of single-reduction geared turbines which operate with dry saturated steam from 24 boilers arranged in four compartments. The total weight of the machinery with water amounts to 5350 tons, equivalent to 13 percent of the displacement. The machinery thus develops 27 shaft horsepower per ton of weight.

In connection with the use of reduction gearing for the machinery of monster vessels of very high horsepower, it has now been clearly proven that geared turbines can be built which will effect considerable savings in weight, space and fuel consumption, compared with any other type of propelling machinery.

HENRIK GREGER: It is brought out in the paper that "the limit of the airplane carrier should be in the neighborhood of 600 feet, and, if accepted, with the speed requirements of about 25 knots. This will bring the profitable aircraft carrier around 10,000 tons standard and with an approximate maximum standard displacement of 14,000 tons." Deducing from the information given, such a ship would require approximately 50,000 shaft horsepower. During the last year, rapid developments have been made in double-acting, two-cycle engines in concentrating large powers, with small weight per horsepower in small floor space. The difficulties of scavenging two-cycle engines at high speed have been solved and several installations are being made abroad.

The German Admiralty is having eight Diesel engines built aggregating 70,000 horsepower to be installed in new high-speed cruisers which are now being constructed.

For airplane carriers requiring 50,000 shaft horsepower, the required horsepower could be developed in six engines, each engine direct connected to a generator and the power transmitted to motors for driving the propellers.

Design of Flying Boat

By Captain H. C. Richardson, (CC) U. S. N.

An abstract of this paper will be published in an early issue.

Discussion

CAPTAIN EMORY S. LAND, (C.C.) U. S. N., called attention to the many parallels between the problems of flying-boat construction as outlined in this paper with those of the naval architect and marine engineer. This country is far behind Europe in the construction and operation of aircraft of this type and the shipbuilders of the country might well become actively interested in the development of this branch of air transportation which is so closely allied with their own. Europe is going ahead with flying boats, having capacities up to 80 passengers, and new ships which are being designed and built in several European countries go as high as 80,000 pounds in weight. In lighter-than-air-craft the shipyard is well adapted to enter the field, for the problems are well within the province of the naval architect. It is time for the shipbuilders to become affiliated with this new and rapidly growing industry.

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Written discussions of Captain Richardson's paper were also received from Lieutenant R. D. MacCart, U. S. N., Lieutenant Lloyd Harrison, U. S. N., Lieutenant W. S. Diehl, U. S. N., I. M. Laddon, and W. D. Clark.

The Inclining Experiment

By Rear Admiral John G. Tawresey, (CC) U. S. N., Retired

An abstract of this paper will be published in an early issue.

Discussion

PROFESSOR W. F. OWEN mentioned a number of experiments in which the men taking readings were hesitant in doing so while the plumb bobs were in motion. It was found in checking readings after the individual operators have gained experience that, by placing a scale behind the bob, the mid position can be determined with more or less facility. Professor Owen also outlined the inclining experiments carried out on the submarine *G-4* a number of years ago, when it was very essential that the metacentric height should fall within certain prescribed limits, a penalty being imposed for variations from this. The first experiment was not entirely successful and a check was made by placing the ship in dry dock and inclining it longitudinally.

WILLIAM BINLEY, JR.: We have usually considered the track method of moving the inclining weights to be superior but perhaps a little slower on the whole than moving the weights with the crane, but if the author's suggestion is followed that no attempt need be made to come to any exact predetermined point for the car, the time can be cut down.

RALPH A. MILLER explained the inclining experiments that were carried out on the steamship *Malolo* when this vessel was being completed at the yard of William Cramp & Sons. In this case two tanks filled with light oil were used as the movable weights and were found to be very satisfactory. The same system was used for inclining the steamship *Yarmouth*. In the case of this ship, the movement of the plumb bobs was so erratic that the points on the curve were not satisfactory, so that the movement of oil as it was pumped from one tank to another was plotted instead. The Steamboat Inspection Service, however, was not satisfied with this method, so conventional weights were utilized when the steamship *Evangeline* was being inclined. The figures obtained in this case approximately coincided with those taken on the *Yarmouth*.

J. S. DICKIE: We are now practically compelled to assure the government of the stability of vessels carrying passengers. As it is proposed that a law be enacted which will demand a minimum stability, the inclining experiment will have a different status in the future than it has held in the past.

HENRY C. ADAMS: Unless a car or some means of moving the entire inclining weight is used so that the inclining moment for any move can be quickly calculated, it would seem to me that the benefit of the check diagram is largely lost through the increase in the time required for the experiment by this method.

The method I have usually seen employed for getting the mean readings is to treat each pendulum and each move as an independent experiment. That is observations 1-2, 2-3, 3-4, 4-5 for each pendulum are each treated separately and the GM's obtained. The mean for each pendulum for each move, and the mean of these means gives the mean of the experiment. Of course any individual values that differ widely should be eliminated in taking the means.

COMMANDER H. E. SAUNDERS (CC) U. S. N.: The greatest single problem in an inclining experiment is the determination of the exact condition of the vessel in so far as pertains to amount and position of weights, liquids, free water, stores, etc.

For the past ten years or more on ships up to about 8000 tons displacement, the writer has utilized mooring lines attached to the vessel as nearly as possible at the level of her center of gravity. This has been accomplished by the use of large C-clamps screwed to the stem for the forward mooring lines and by the use of the rudder stock or padeyes for the propellers or mooring staples near the waterline for the after mooring lines.

For inclining experiments on submarines, some of which are now larger than the smaller surface vessels of the Navy, the Navy Yard, Portsmouth, has devised and employed with great success a special set of inclining weights constructed by using the trucks and wheels of the cars from an abandoned coaling plant.

With regard to the methods of indicating and recording angles of inclination, it has been felt for some time that pendulums are not sufficiently efficient to justify the labor spent in observing them. One standard optical clinometer, having a very short period, will give practically as much weight as the combined readings from several pendulums.

One great advantage of all classes of optical instruments for taking observations is that they can be more readily set up in the vicinity of the inclining weights than can pendulums; hence check signals can be made visually betwen those at the inclining weights and those at the instruments and the observations can be begun almost immediately after the weights are in position.

C. H. ROUNDY: It is believed that a portable recording gyroscope will give accurate metacentric heights with a minimum of effort and time. Whether an entirely suitable instrument has been developed for the purpose of obtaining stability data is not known.

Another thing not covered in the paper is the period of roll. This value may be obtained at time of inclining by an observer equipped with a stop watch, noting the time of a series of rolls.

Ships with negative metacentric heights are not referred to, possibly because they are seldom encountered on inclining experiments; yet cases are on record of inclining ships with negative stability. A plot of inclining experiment data was devised about ten years ago to detect errors in readings during the progress of the experiment. The discussion by Mr. Roundy continued with a demonstration of this method.

H. E. ROSSELL: Experiments which are long drawn out are not only costly but are apt to be far less accurate than ones handled expeditiously even though the latter may be based on a lesser number of observations. The reflecting pendulum seems to possess considerable merit primarily because of the speed with which observations can be taken. As far as accuracy is concerned, the conventional type of plumb bob pendulum is satisfactory, but the time required to obtain readings from its scale is usually excessive even when damping is obtained by some such device as suspending the bob in oil.

J. L. BATES: To the designer the accurate location of the center of gravity, particularly in a vertical direction, and the careful determination of the displace-

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ment are of particular importance because these serve both as checks on the calculations already made and as the basis for future work. Accordingly, the writer regrets the emphasis placed upon time saving, in so far as it decreases the likelihood of securing the data just mentioned.

For the same reason the writer takes this opportunity to stress the importance of ascertaining accurately the ship's condition at the time of the experiment as to loading, degree of completion, etc.

Additional points of importance are the accurate reading of the draft and the correction for the mean density of the water in which the experiment is performed.

PROFESSOR WILLIAM HOVGAARD outlined the procedure for an inclining experiment when the ship has an initial inclination. The mathematics of this condition are thoroughly covered and should serve as a basis for conducting an experiment of this character.

C. E. PETERSEN: It was my privilege to be associated with Admiral Tawresey when the reflecting mirror pendulum illustrated in the paper was used on the inclining experiment performed on the United States liner *America*. Since then I have had an opportunity to use the same reflecting mirror pendulum on the inclining experiment performed on a small steamer of 1791 tons displacement. In that inclining, the shipyard's hull technical staff performed the experiment in accordance with their usual practice, using three plumb bob pendulums, located one forward, one amidships and one aft. The purpose of using the reflecting mirror pendulum was to obtain further data as to how the results obtained from its use compared with the results obtained in the ordinary way. The results showed that the average G. M. resulting from the use of the plumb bob pendulums is 2.261 feet whereas the G. M. resulting from the use of the reflecting mirror pendulum is 2.259 feet. Direct observation and study of these tests, where the reflecting mirror pendulum was used, force the opinion that the ordinary method of using plumb bob pendulums in an inclining experiment can be superseded by the single reflecting mirror pendulum, and that greater accuracy will be obtained, and the time of the experiment will be greatly reduced by its use.

HUGO P. FREAR: A very fair approximation of the metacentric height can be arrived at from a well-known formula by observing the rolling period, and with good luck even by calculation, but the determination of the center of gravity and metacentric height by an inclining experiment is generally conceded to be the conclusive check regardless of minor errors.

Initial stability, great or small, is not necessarily a criterion of either safety or danger. Things can happen in both cases, with improper loading. Barring open ports and in case of damaged open doors, the behavior at sea of a vessel is as good a criterion of stability as any, and better than calculations unless based on actual and similar cases.

If it is conceded that a fair approximation to the metacentric height can be determined from the rolling period, a means of getting the rolling period under all conditions, even when there is no apparent roll, either at the dock or at sea, would be of incalculable benefit.

It seems that a reflecting pendulum such as Rear Admiral Tawresey describes might, if permanently installed on a vessel, possess the necessary delicacy and accuracy to offer a ready means of solution.

A. H. VAN KEUREN: There is another phase of the subject of inclining experiments that deserves some further study than has heretofore been given to it. I refer to obtaining as accurately as possible, the displacement of the vessel and the position of its center of gravity, both vertical and fore and aft, for a standard basic condition, from which data for any condition of loading or any condition of damage may be calculated. For this purpose it is necessary to obtain with all the accuracy possible the true displacement of the vessel as inclined, and the weight and position of all articles on board at time of inclining, and all articles which remain to be placed on board to bring the ship to the basic condition.

W. GATEWOOD: The accuracy of the inclining experiment is vitiated if the inclination is increased by the movement of an unknown quantity of water or other liquid in the vessel, and the check diagram, while of use in showing the presence of loose water, does not, in my opinion, render unnecessary the utmost care in the preparations preceding the experiment.

Four readings under proper conditions should furnish the necessary information; and seven readings would supply a double check in case there is any doubt as to the accuracy of any of the early readings.

Additional written discussions were received from E. H. Rigg, H. F. Norton, and J. F. Arringdale.

Propeller Backing Power In Tug Boats

By Alfred J. C. Robertson

This paper will be published in an early issue.

Discussion

REAR ADMIRAL D. W. TAYLOR, U. S. N.: The data given are complete but apparently refer only to one trial for each condition. I am inclined to think that the eccentricities pointed out by the author would be toned down, if they did not disappear, if this was one of a series of models or if the trials for the five conditions had been repeated several times.

Wake and thrust-deduction coefficients depend upon measurements requiring extreme accuracy if they are to be exact and consistent throughout, an accuracy perhaps beyond the capacity of existing apparatus.

Questions of wake and thrust deduction are perhaps the most obscure in the field of propulsion, and it is hoped that it will not be many years before they are much better clarified than at present.

It is noted that the tug is much broader in proportion to its length than the ordinary sea-going type of vessel and also of very light draft. These hull features might account for some of the eccentricities pointed out by Mr. Robertson.

PROFESSOR E. M. BRAGG called attention to the similarity of wake values given in his paper of 1924 with those of Mr. Robertson. He commented on various conditions discovered by the author during his wake tests of the tugboat model.

W. W. SMITH indicated the various methods to follow in estimating propulsive performance when it is not possible to conduct model tests. For propulsive or combined performance there are practically no data except that given in the paper. For hulls that are different than the one tested, hull coefficients for going astern may be approximated from normal ahead coefficients.

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Performance of Shipping Board Motor Vessels

By Captain R. D. Gatewood

An abstract of this paper is published on page 656 of this issue.

Discussion

JOHN L. BOGERT compared the oil consumption of various types of engines mentioned in the paper and requested further data on the differences shown. A comparison was also made between the Diesel drive and the geared-turbine drive with Diesel oil at $2 per barrel and with bunker oil at $1.

J. H. KING: The first cost of a ship is one of the primary considerations in determining whether or not the ship can be operated at a profit. We, therefore, must consider whether or not the Diesel engine has any advantages over a good steam installation as a means for propulsion.

The facts indicate that modern steam propulsion has many advantages over the Diesel. For some time past central stations ashore have been making rapid strides in increasing economy, and the limit of this economy has not as yet been reached. The progress afloat has not been as rapid with steam as it has been ashore, but the principles that have so thoroughly been proven on shore stations are now showing their practicability and great economy in actual installations afloat.

More than a year ago, two of our foremost shipyards, in conjunction with turbine and boiler manufacturers, made a proposal to the Shipping Board to equip a 3300-shaft-horsepower freighter with higher pressure, geared turbines and boilers. Such a ship would be exactly the same type as those converted to Diesel. This ship would operate with boilers built for a working pressure of 400 pounds per square inch, equipped with superheaters to give 230 degrees F. superheat and with air heaters located on top of the boilers. The geared turbines proposed were of well-known types and the auxiliaries would be largely electrically driven.

With this installation the builders are prepared to guarantee an oil rate of 0.63 pounds of oil per shaft horsepower for all purposes. The cost of this conversion would be only about 70 percent of the cost of converting similar ships to Diesel engines.

In a vessel propelled with a modern steam installation, the first cost, which determines our fixed charges, would be considerably less than the Diesel plant; the operating costs both for fuel and wages would be less than the Diesel plant; the upkeep and maintenance would certainly be less than the Diesel.

After considerable thought and study, the Panama Pacific Line has concentrated on the construction of steamships. They already have one and are building two more fine steamships. This fact is particularly notable because these ships operate on a long run where the Diesel engine advocates claim superiority for the Diesel.

The Southern Pacific Company investigated the possibilities of the Diesel engine for their service and although they have large oil interests they have built modern steamships, such as the *Dixie*.

The Matson Line after very careful study of Diesel engines are now calling for bids for ships for the long run to Australia to be equipped with a steam plant in which the shipbuilder must guarantee a fuel consumption of not over 0.65 pound of oil per shaft horsepower hour for all purposes.

The Dollar Line with their extensive services and long runs are also contemplating the construction of steam-propelled tonnage.

ELMER A. SPERRY in a general way defended the position of the Diesel engine in marine practice and prophesied a wider expansion of its use in the future. The Diesel engine manufacturers in this country are only beginning to reach their stride and the future possibilities are only now beginning to become apparent. In Europe, Junkers is actually building Diesel engines for aircraft service weighing only 4 pounds per horsepower. The British designers have also developed certain light-weight Diesel engines to a high point and have also reduced weight materially. Supercharging, such as applied in the Büchi system exhaust-gas charger, will accomplish remarkable results and increase the efficiency and power of Diesel installations to a degree never thought possible before.

HARTE COOKE: Captain Gatewood's paper brings out one point, i.e., that the operating personnel at sea at the present time is not as familiar with motorships as with steam vessels, due to the rapid increase in the number of motorships.

The Shipping Board's arrangement of carrying a fourth engineer, to increase the available trained personnel for motorships, will very soon create a personnel so that motorships will be on the same basis as steam vessels in this respect.

Also the co-operation of the manufacturers with the operators constantly tends to improve the operation of motorships, as time goes on, so as to improve still further even the good record that Captain Gatewood has shown in his paper.

E. NIBBS: As a manufacturer of one of the engines concerned, I feel an explanatory remark is necessary regarding the design of the entablatures of the M.A.N. type double-acting, two-cycle engine referred to by the author in his paragraph under maintenance. The re-design of the entablatures for this type of engine was initiated by the M.A.N. Company during the building of the engines for the *Wilscox* and *Seminole* in this country solely in an effort to reduce the cost of manufacture, and not on account of any experience afloat in either domestic or foreign built engines of this type.

The engines of the *Wilscox* and *Seminole* where referred to in the paper, being labelled simply "M.A.N.," gives the idea that they are foreign built. H.O.R.—M.A.N. and Velseco—M.A.N. used as a descriptive title would render them, insofar as nomenclature is concerned, the same as the Busch-Sulzer product.

It is interesting to note that the four, two-cycle, single-acting engined ships averaged 99.85 pounds of fuel per mile with a minimum of 96.4 pounds. The three, four-cycle, single-acting engines averaged 117.3 pounds per mile with a minimum of 111.2 pounds. Two two-cycle, double-acting engines of one make averaged 118.8 pounds per mile with a minimum of 110.2 pounds; one four-cycle, double-acting engine 124.3 pounds per mile, and two, two-cycle, double-acting engines of another type 127.9 pounds per mile. I believe there is no reasonable doubt that these figures will be somewhat improved as time goes on.

It is interesting to note that the average speed of the *Wilscox* was 12.49 knots over a 13,000 mile voyage; while the *Seminole*, engined in a similar manner,

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exceeded 12 knots over 28,000 miles, while none of the others reached this figure. Of course this is natural, as the two vessels named had greater power than the remainder; but it indicates that for similar vessels the excess power has been installed in these ships in the same space allotted for the machinery of all types.

Chief engineer, J. Brown and first assistant D. Donelly have been shipmates for the three voyages listed in the *West Honaker*. No other ship can claim this distinction up to date, and only in one other ship, viz: the *Tampa,* has the engineering staff been the same for two consecutive voyages. I believe that here is a chance for those responsible to improve the conditions so that such a turn-over of the engineering staff in these vessels will not occur again.

The lubricating oil consumption should be reduced. The records show wide variation, even for similarly engined ships. Part of this may be due to different qualities of lubricating oils, but I believe that it is chiefly due to the personnel having different ideas as to what constitutes a margin of safety.

C. H. STEVENS in reply to a former question on the differences in speed of the ships of the converted fleet, explained that different propellers were used; that the fineness of lines and shape of the stern on certain of the ships made higher speeds possible than in the case of others; and that to a large extent the engines did not enter the problem of speed differences in any great degree. Each case should be studied separately. He disagreed with the former statement made, that Diesel ships of over 1000 horsepower were not practicable; for every evidence available indicates excellent results in high powers. Engine repairs on the Diesel ship, he said, are in general no higher than in the case of a steamship.

H. SCHRECK explained that in the case of these ships the high lubricating-oil consumption should be charged to the inexperience of the operators and their desire to have the new engines work satisfactorily. Figures will probably be available later that will show a better fuel consumption than has so far been obtained. Another explanation of the rather high fuel consumption is that, if fuel valves are not exactly adjusted, the very small amount of additional fuel used with each stroke will over a day's run make considerable difference. It is difficult for new men to make adjustments on fuel valves at sea. The engineer staff should seek advice and improve this condition wherever possible.

In Germany a Diesel engine has been built which for four years has been operated on pulverized-coal fuel. The results of tests over this period have been presented before engineering societies in Europe and will also be presented in this country before the Coal Association. The only changes in the engine are in the cylinder head so that present power might readily be converted to use this fuel which would reduce fuel costs to about one-third of what they are now. With this type in use it will also be possible to compare one Diesel engine with another operating on oil and on pulverized coal.

ADMIRAL W. S. BENSON, U. S. N.: My reason for initiating the Dieselization program was prompted by the fact that all maritime nations were rapidly supplying their merchant service with motor vessels. It was quite evident that if we did not follow suit we would be left out of the race completely. I felt that only the Government could afford to go to the expense of undertaking such a costly effort. By converting about twenty-five vessels, every fairly well tested type of Diesel engine could be given a trial. We would thus not only educate our designers and mechanics in the art, but from the data obtained in actual service private capital would be able to draw its own conclusions as to the relative economy and the best type of motor to adopt.

The question of the types that should be tried was left to a committee of experts, and when finally decided upon, Captain Gatewood was requested to take charge of the program, select and organize the necessary experts and assistants, and take complete charge of all technical details, and to him and to his experts is entirely due to the success of the undertaking. Please remember that Captain Gatewood undertook this work in addition to his gigantic task in charge of the repairs and maintenance of the entire United States merchant fleet.

W. W. SMITH: It would be desirable to have more definite information about the major changes made in the engines, including the reasons for making them, so that those who install Diesel engines in the future may avoid these faults.

It has often been claimed that the cost of the engineers force on a Diesel ship is substantially less than on an oil-burning steamer. It is noted in the paper that the cost on the Diesel ship, omitting the fourth engineer is $1385, and that the average cost for the oil-burning steamers is $1396. Thus, there is practically no difference.

It would be desirable to have the total number of days these vessels have been in service, the average shaft horsepower, and the fuel consumption in pounds per shaft horsepower. The two latter values are considered better indices of engine performance than the values given.

The most important factor in the problem, that of operating cost, is omitted for reasons given, but it is hoped that the author will add the essence of the matter later.

In general, the operating results of these ships, both mechanical and economic, seem to be excellent. The carrying out of such a large pioneering program with such uniformly good results is highly creditable to Captain Gatewood, and to all others concerned.

CAPTAIN R. D. GATEWOOD explained that the tables given in the paper must be studied with discretion and that it is relatively hazardous to average the results. The differences in fuel consumption and in speed are due to the fact that the hulls in all cases are not the same, the propellers are different and the personnel has had various degrees of experience in Diesel work. The board is not satisfied with the results so far obtained and will seek to establish a set of standards for the Diesel ships that will be similar to those now in force on the steam-driven vessels of the Shipping Board fleet. All vessels should be brought up with the best vessel in the fleet and the vessel which at present has the best record must be better before the department will be satisfied. On the question of bunker oil, the operating department absolutely refuses to consider its use in Diesel engines aboard these vessels. It is better to pay more for the proper Diesel oil and to make fewer renewals.

Captain Gatewood then outlined the various prices today for fuel oils at different ports of the country. The price of lubricating oil is too high and one best lubricating oil should be developed for all auxiliaries and main engines rather than the variety that is now required by the builders for the different machines.

In continuing, Captain Gatewood stated that the purpose of the present discussion, as outlined by Mr.

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Sperry, is to arrive at the ultimate engine. At the present time neither the Diesel engine nor the steam engine has reached this point in its development. The progress made in developing reliable Diesel engines has helped materially to stimulate interest in steam propulsion and in this way the present program has certainly aided in paying for itself. In order to go on with further installations and to warrant putting these engines in ships 10 or 12 years old their cost should be reduced. In spite of this, the present Diesel program of 12 ships completed and 8 in process of completion will at their present cost pay for themselves within 14 years at most, always taking into account the price of fuel oil. The new engines which are being developed will be superior to the first and all the troubles found in the case of the earlier engines have been eliminated in the new ones.

Development of Pulverized Fuel for Marine Purposes

By C. J. Jefferson, Commander J. S. Evans, U. S. N., and Commander J. Broshek, U. S. N.

An abstract of this paper is published on page 646 of this issue.

Discussion

T. B. STILLMAN: A more complete description of just what happened with 13,000 B.t.u. coal, compared with the better grades, would be of unquestionable value for future guidance.

The authors have made a most interesting comparison between the 1928 League Island and the 1927 Bayonne boiler efficiencies. Applying the authors' method of comparison used in plate No. 13, the second slide shows in the lower section a comparison of total radiation and unaccounted for losses (including carbon losses up the stack) of the 1927 League Island and Bayonne tests. The upper portion of this slide shows a similar comparison of the uptake-gas temperatures of the same two series of tests. The most striking thing about these curves is the fact that although the gases leaving the air heater of the Scotch boiler are 50 degrees cooler than the gases from the Babcock & Wilcox boiler the efficiency of the latter is 4 percent better than the Scotch boiler. The reason for this is clearly brought out in the lower portion of the second slide, the large unaccounted for and carbon losses from the Scotch boiler more than counter-balancing the benefit brought to this boiler by the air heater in the form of low uptake gas temperatures. The Babcock & Wilcox boiler had neither air heater nor economizer.

It should be emphasized at this point that the fineness of pulverization of the coal used in both these 1927 series was about the same, the Scotch boiler having slightly finer coal at the rates common to both series. By increasing the fineness of pulverization from about 80 percent for the 1927 tests to 90 percent through a 200-mesh screen for the 1928 tests, the efficiency of the Scotch boiler with air heater was raised so that it was comparable with the Babcock & Wilcox boiler without an air heater and burning coarser coal, the same burner being used in both installations.

The statement on the first page of the paper, that the small furnace volumes available under watertube marine boilers make it practical to adapt shore practice to their use, is quite correct. The difference in the speed of combustion required is the secret of this.

The suggestion that tests run at higher rates of evaporation than those reported last year in the Bayonne paper be made is well taken, but it should be recalled that in that report it was stated we could not go to higher rates than those reported, because of slag on the tubes shutting the boiler down in short order, even when coals having high ash fusing points were used.

After presenting the paper last November, in which attention was called to the desirability of further experiments with water-cooled walls, we proceeded to conduct such experiments during January, 1928, using both low and high fusing point coals. The results showed that cooling 50 percent of the side walls had very little effect upon our slag problem. If low fusing point coals were used, we were still facing a slag condition on the floor and tubes which was not practical for a seagoing installation. The small amount of cooling used undoubtedly did move the critical slag temperature of the ash downward a trifle, but not enough to be of any practical value.

At the very low rates, there was a slight gain in efficiency, but by the time normal operating rates were reached a distinct loss in efficiency had occurred, amounting to 2 percent between the 5 and 6 pounds of water per square foot of heating surface rate. To put the matter frankly, we were rapidly approaching the Scotch boiler furnace disadvantages, where it would be necessary to add air heaters and over-sized mills to make up for the efficiency we were losing due to the cooling of the walls.

Particular attention is called to the fact that cooling these walls was not a disadvantage from an efficiency point of view at moderate rates of B.t.u. per cubic foot of combustion space, and was in fact an advantage at the very low rates. This confirms the present procedure in stationary practice, where water walls, especially of the refractory covered type, have been found of distinct advantage at rates of 20,000 to 30,000 B.t.u. per cubic foot of combustion space. But when rates in the neighborhood of 60,000 B.t.u. per cubic foot are encountered, as in marine boiler furnaces, under normal operating conditions, very much higher speeds of combustion are necessary, and the furnace temperatures must be maintained as high as possible to insure them. This condition is not peculiar to pulverized coal, as we have observed exactly the same experience in adding cooling surface to an oil-burning furnace which was used at the higher rates.

One might say there is no particular objection to telling a shipowner that he needs water-cooled walls in marine furnaces, induce him to use them and then load him up with large air heaters and oversized, inefficient mills in the attempt to recover the boiler efficiency which has been lost due to the use of the water walls. However, this could certainly not be regarded as good commercial engineering, and it is for that reason that the two pulverized coal installations at present being made on ships by the company with which the writer is associated, under boilers of their manufacture, are using insulated brick furnace walls, with moderate-sized air heaters and moderate-sized, efficient mills, manufactured by the Fuller Lehigh Company. The latter will give relatively fine coal at their designed rates, but will not waste power producing the excessively fine coal which would be necessary had water or air-cooling of the walls been resorted to in the relatively small furnaces available.

E. H. PEABODY stated that he had spent a good deal of money in this development work and that the Government had not done it all. With regard to the length of time of tests with pulverized coal he believed that from one-half to 1½ hours is ample. He described the steps that were taken in experimenting with distributors

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and stated that the difficulties encountered were of a mechanical nature as they were unable to make a stuffing box tight against coal dust, which penetrates like kerosene but stays there and stops the test.

PROFESSOR L. B. CHAPMAN called attention to the fact that last year shipowners were especially interested in coal, as oil was high, whereas this year oil is low. Assuming the fuel consumption per horsepower-hour in good practice as 0.8 pound for an oil-burning ship and 1.07 pounds for a coal-burning ship, he compared the influence of fuel costs in various parts of the world, as follows:

	United States (Atlantic Coast)	United Kingdom	United States (West Coast)
Oil-burning ship	1.00	1.00	1.00
Coal-burning ship	1.06	0.36	0.86
Diesel-engined ship	1.04	0.63	0.58

He believed that these figures would also apply to pulverized coal with the same boiler efficiency. There is one criticism against this figure, however, and that is that the power for the pulverizer is high.

MR. JOHNSON stated that proper distribution means a proper ratio of air and coal and fineness of coal, and criticised the types of distributors illustrated in the paper as being developed on a wrong principle, making them merely deflectors. The Kennedy-Van Saun Corporation, he explained, has developed a distributor on a new principle. This takes a shot of coal and puts it down one pipe, and then another shot down another pipe and so on, the frequency being so great that the method of distribution does not interfere with steady combustion.

R. M. HARDGROVE: The distributors developed at League Island during the last year have marked real progress and we are looking forward with a great deal of hope for the scheme mentioned in the paper of making the split right at the mill, the mill being under pressure. This will eliminate the exhauster blade referred to.

In comparing the results obtained at Bayonne with those at League Island we would like to add a few comments. The mill used at League Island has a capacity 50 percent larger than the one used at Bayonne and, for the same output, finer coal is obtained. If we compare the last test on Pocahontas coal reported by Mr. Stillman made at a rate of approximately 1200 pounds of coal per hour with a 6½-hour test at League Island at the same rate we find the Bayonne installation gave an efficiency of 80.3 percent compared to 77.7 at League Island though the coal at Bayonne was 77.6 percent through 200-mesh and it was 89 percent through 200-mesh at League Island. The heat loss due to combustible in the flue dust at Bayonne was 2.0 percent while it was 9.7 percent at League Island. If coal of equal fineness had been obtained the difference in carbon loss would have been still greater.

For these same two tests the liberation in B.t.u. per cubic foot of furnace volume per hour was 63,876 at Bayonne and 36,950 at League Island, this latter figure being based on the combustion chamber volume plus the furnace volume. Thus the watertube boiler gave a higher efficiency that the Scotch boiler although handicapped by a smaller furnace volume, higher excess air, coarser coal and no preheater. This indicates the advantages of a hot furnace over the completely water cooled furnace of the Scotch boiler.

The need for a "grindability" test mentioned in the paper is real. A little over a year ago we experimented with several different types of laboratory equipment for determining relative grindability with the result that we adopted a motor driven mortar and pestle as it proved to give the most consistent results of the several types tried. The procedure is as follows:

A 50-gram sample of coal that is sized through 16-mesh and on 30-mesh is placed in the mortar and the pestle is dropped 800 equal strokes at a definite rate. The sample is then screened and constants applied to the quantity of each size obtained, these constants being reciprocals of the size of the particles. The sum of these products is the total work units obtained which can then be compared for different coals. If we call an 18 percent volatile coal from Somerset County 100 percent grindability we obtain results as low as 27 percent for some of the hardest Kentucky coals having 39 percent volatile. Illinois coals run 50-60 percent and Western Pennsylvania coals about 50 percent.

During the last year, coals from all over the country have been tested and we find the results bear a definite relation to mill capacity although the variation in mill capacity is not as large as the variation in work units. We find this test of great value in estimating capacities and fineness that will be obtained with a given coal.

MR. VROOM compared the results obtained with impact and ball pulverizers.

C. J. JEFFERSON agreed with Mr. Stillman that a change in combustion rate would not take place with change in heat content. This should be changed to a change of firing rate. The chart presented by Mr. Stillman showing a comparison with Fuller-Lehigh equipment on a watertube boiler was interesting but not conclusive. He pointed out that boiler tests cannot be compared unless the conditions are identical. Six-hour tests are not long enough. In these tests the Shipping Board has spent ten times as much money as have private interests but he urged private interests to carry on the work. The mechanical distributor, he said, is a good distributor, but, like President Coolidge, it did not "choose to run." He approved the standard of grindability proposed by Mr. Hardgrove.

COMMANDER BROSHEK stated that tests of less than one-half hour were discarded and of from one-half to one hour are looked upon with disfavor. Conditions must be steady before test data are taken. A distributor that is merely a deflector is useless. He asked if the distributor described by Mr. Johnson has been tried out; it didn't look to him as if it would work.

The Burning of Hydro-Carbons Under Marine Boilers

By E. H. Peabody

An abstract of this paper will be published in an early issue.

Discussion

C. J. JEFFERSON: The paper deals largely with the subject of mechanical reduction of solid fuels and an elaboration of an opinion as to the necessity of fineness of grind of the fuel for satisfactory combustion in a marine boiler. Stationary plants using large-sized, refractory-lined furnaces, and having long flame travel, can handle relatively coarse coal, but in the case of the small-size furnace of the marine type boiler, further aggravated by the entirely water-cooled surface as in the Scotch boiler, fineness of grind is a fundamental principle and not an opinion. Mr. Jefferson presented data that established the fundamental principle which states that much finer coal is needed for the marine boiler than that

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which can be used with a certain degree of satisfaction in the large furnaces of the stationary boiler.

The effect of fineness of pulverization on radiation in the pulverized fuel furnace has been thoroughly discussed by Professor Wohlenberg in several papers presented before the American Society of Mechanical Engineers. I would especially refer to the paper presented by him at Milwaukee in May, 1925, in which is shown the relative radiance of flame particle sizes, showing an increase of about 70 percent in the relative radiance, obtained by decreasing the size of the particle from 0.005 to 0.00071 inch.

H. B. PEARSON, JR.: In the closing paragraphs of this paper, the "unit bin" system is referred to. This system came into being as a result of unofficial reports of difficulties experienced in the *Mercer* and *Lingan* installations in splitting the initial air current from the pulverizer into the several streams required for the individual burners. It appears to be essential that the heat release should be equal in the several furnaces of a Scotch boiler.

Splitting an air current laden with powdered coal into several streams, where the weight of coal and volume of air are equal in the several splits is obviously difficult. In the unit bin system the coal may be definitely measured by mechanical feeders so that, in Scotch boilers, the heat release in each furnace will be identical, or can be shut off as required.

The system consists of an air-swept pulverizer, a cyclone separator delivering the powdered coal into suitable small bins, an exhaust fan to supply the required air current through the pulverizer and cyclone separator and the fan discharging to the primary air duct of the burners as is practiced in the unit system and not into the pulverizer as in the central or closed-circuit system. The units are connected in sequence by suitable air ducts. With the provision of bins for the storage of excess coal, a condition is created that permits the pulverizer to operate at maximum capacity which is, of course, maximum efficiency. This will permit the pulverizer to be shut down at regular intervals.

MR. JOHNSON referred to Dr. Work's experiments in which the ball type mill showed the highest proportion of impalpable powder and the impact mill the lowest. Again the ball mill showed a low ost of maintenance and the high-speed impact mill a high cost of maintenance.

MR. VROOM said that he held no brief for either type of pulverizer. The fineness of pulverization was about the same in both.

MR. PEABODY felt that the impact mill was thrown out too suddenly. The impact mill is now running at 3600 revolutions per minute, whereas a year ago 1800 was considered out of sight. Power, he believed, is the controlling element.

Forced-Blast, Chain-Grate Stoker Tests of a Marine Watertube Boiler

By T. B. Stillman

An abstract of this paper is published on page 642 of this issue.

Discussion

W. W. SMITH asked if "C" tiles would be used with heated air and if high efficiencies could not be obtained with water walls? A mechanical ash conveyor is a very desirable device, he said, as it eliminates hand labor, which is very important. Complete mechanical equipment for handling both coal and ashes should be installed, if the best efficiency is to be obtained. Mechanical stokers are extensively used on land, so there is nothing novel or untried about them. As shown by the performance of the stokers on the *Bradley* they also operate very satisfactorily on ships. The heat liberation of 147,000 B.t.u.'s per cubic foot he considered a very high value, compared with about 60,000 for oil or pulverized coal. If the boiler efficiencies with the chain-grate stoker average about 2 to 3 percent less than with pulverized coal, is it not possible to increase this efficiency somewhat by using a larger furnace? The efficiency is about the same for the two on shore. The boiler efficiency, however, does not tell the whole story; the power required enters into it. If this stoker were applied to the type of boiler installed on the *Bradley* with air heater, etc., the boiler efficiency would be 84.1 percent. Maneuvering with the stoker is an important feature; its suitability was well shown on the *Bradley*. The statement that the difference in fuel consumption between hand firing and stoker firing is 10 percent should be qualified by the fact that this refers to the best hand firing. With stokers, the saving in the fire-room force, including wages and sustenance, is an important item. The tests recorded in the paper were conducted in a thoroughly scientific manner. Basic values are given in the tables and curves.

C. J. JEFFERSON recalled a series of tests that were carried on jointly by the United States Shipping Board and the Bureau of Mines in 1918, using a type D underfeed stoker under an E. F. C. watertube boiler. The tests conducted by Mr. Stillman cover a range of equivalent evaporation up to 7 pounds per square foot of heating surface while the earlier tests cover a range up to 10.49 pounds of equivalent evaporation per square foot of heating surface. The latter part of the efficiency curve for the E. F. C. boiler tests are practically a continuation of the B. & W. tests. At the lower rates, however, the B. & W. tests show an advantage of about 2.3 percent and at the 7-pound rate of evaporation an advantage of about 0.50 percent, which would indicate the progress that has been made in stoker combustion during the past ten years, part of which may be due to the fact that the B. & W. boiler was equipped with superheater while the E. F. C. boiler did not have it, and, further, it is a recognized fact that the B. & W. watertube boiler is probably one of the most efficient straight-tube boilers manufactured, while the E. F. C. boiler was a wartime measure created to help meet the boiler demand for the vessels of the emergency fleet.

In contrast to the development that has been made with stokers during the past ten years, the rate of evaporation per square foot of heating surface with pulverized coal as applied to Scotch boilers since 1921 has been increased from 3.5 to 8 pounds and the efficiency has been increased from 54.4 up to 79.4 percent.

MR. GRIFFITH: There is just one point I should like to emphasize, and that is the fireman's view of this method of firing. There is no doubt that the morale of the fireman is responsible for an increase or decrease of efficiency in coal burning just as much as some items of the heat balance. This method of firing is apparently a fireman's friend. The fireman of today having tasted somewhat of the luxuries of life is no longer the fireroom slave of former years, reconciled to a sentence of hard labor with shovel and slice bar. He is striving for that same freedom from manual labor which is sought in

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every other occupation. That the fuel bed during these tests was regulated entirely by air-control, that the slice bar was entirely forgotten during the burning of this coking coal, that the fireman remained in a happy frame of mind are outstanding factors tending toward both economy and efficiency. In conclusion, the Pocahontas coal used in this test was an air-cleaned ½-inch slack of less than 6 percent ash content, and about 2400 degrees fusion temperature. Since we are prone to make comparisons with hand-firing, it is interesting to note that this size could not be burned with any reasonable efficiency in a hand-fired installation. Such coal, although of high quality by analysis, is sold on the market at a reduced price over run-of-mine because of its size. Yet you will note that an average equivalent evaporation of almost 11.5 pounds was obtained through these tests. Consider the use of high quality slack in making comparison with oil.

E. H. PEABODY pointed out that slack coal is cheaper due to the fact that it is not applicable to hand firing.

C. J. LAMB stated that slack coal has been burned before on chain stokers.

MR. STILLMAN, in replying to Mr. Smith, stated that the middle west is doing very well with heated air and "C" tiles. Brick walls are used to retain heat for rapid combustion. Water boxes are put on the slag line. A larger furnace is correct. The unaccounted-for losses will come down if the furnace is given greater height.

Referring to Mr. Jefferson's remarks, he stated that residual fuel would not be ideal for marine practice. Coke would take up too much space and would be expensive to pulverize. In the Shipping Board tests ten years ago the rates per cubic foot were lower than those in the tests recorded in the paper.

Turbine-Electric Drive as Applied on the Great Lakes Cargo Ships

By C. R. Fisher and A. Kennedy, Jr.

An abstract of this paper is published on page 679 of this issue.

Discussion

W. W. SMITH: The *Bradley* has many new features which will have an important bearing on the future of marine machinery. The latest land power plant practice, substantially without modification, has been applied throughout. The main machinery is of the high-efficiency type. The boilers have vertical headers which give symmetrical proportions that are advantageous for the spaces available. They also have integral air heaters which give a simple, compact unit of high efficiency—in this case about 84 percent. This type of boiler will give 85 percent service efficiency, and is especially desirable for high-efficiency installations.

Electrical auxiliaries supplied with power by the main turbine give high efficiency of heat conversion, of power transmission, and of fuel consumption. Financially, electric auxiliaries are fully justified for high-efficiency installations. Alternating current is extensively used for auxiliary power, and appears to have some important advantages worthy of consideration, among which are simplicity, ruggedness and low cost.

A very important feature of this installation is the extensive use of labor-saving machinery and devices. It is noteworthy that a coal-burning ship of 4800 shaft horsepower has but one man on watch in the boiler room. Important economies in labor are effected by the extensive use of automatic controls, recording instruments, and integrating meters. The latter save a large part of the labor which would otherwise be required for log records, and they are much more accurate and complete.

Referring to page 2, with coal of 14,000 B.t.u. at 0.2 cent per pound, the cost per million B.t.u. is 14.3 cents. With oil of 18,500 B.t.u. at 0.6 cent, the cost per million B.t.u. is 32.4 cents. Thus, the ratio of cost is 2.27 on a thermal basis, which is the best index to relative fuel costs.

Referring to page 11, with a coal rate of 1.39 pounds per shaft horsepower at 0.2 cent per pound the cost of power is 0.278 cent per shaft horsepower for the *Bradley*. With an oil rate of 0.47 pound per shaft horsepower at 0.6 cent per pound the cost of power is 0.282 cent for the Diesel engine. The latter, however, is lower than it would be for the over-all conditions of this vessel, but is about right for the conditions at sea, for which the fuel rate of the *Bradley* from page 8 is 1.17 pounds. Using the latter value, the cost per shaft horsepower is 0.234 cent; and, instead of being about the same, the cost of power for the Diesel engine is about 20 percent greater than the *Bradley*. Also, the performance of the *Bradley* can be further improved in future installations of this type.

Referring to page 8, the fuel consumption of 1.17 pounds per shaft horsepower is equivalent to 1.05 pounds per indicated horsepower of a steam engine with 90 percent mechanical efficiency. Assuming that an average good steam engine ship will consume 1.7 pounds of coal per indicated horsepower, the consumption of the *Bradley* is 62 percent of this value. Such a large saving in the cost of fuel should compel the attention of shipowners regardless of previous practice or set ideas.

Referring to page 11, hand firing is much less efficient, than mechanical stokers. The relative boiler efficiencies may be taken as 70 and 80 percent respectively for a given boiler. Thus, the ratio of fuel consumption is 0.875, and with a ratio, as given, of 0.80 for the cost per ton, the ratio of total cost of fuel becomes 0.70. Allowing further for wages and sustenance of firemen, the ratio of cost of fuel and labor would probably be around 0.60; or in other words, the cost of hand firing would be about 40 percent greater than mechanical stokers. This large saving is impressive and indicates the use of mechanical firing, either stokers or pulverizers, for coal fuel.

Attention is called to the last two columns in the table on page 13. These data are essential for the proper economic control of any power plant. Here, accurate measure by integrating meters may be contrasted with the usual inaccurate methods which prevail in marine practice.

On Page 8, it is stated that the steam flow, and consequently the boiler efficiency as given in plates 1 to 3, is open to question as to accuracy. The boiler efficiency as well as the loss of 5 percent in fuel consumption due to vacuum is worthy of attention. The expected normal performance of boilers and condenser should reduce the fuel consumption 6 or 7 percent, or from 1.17 to 1.10 pounds per shaft horsepower. With coal of 14,000 B.t.u., the latter value gives a heat consumption of 15,400 B.t.u., and with oil of 18,500 B.t.u., the oil consumption would be 0.833 pound per shaft horsepower.

PROFESSOR A. F. LINDBLAD stated that 13 miles per hour had been shown to be the most economical speed

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for Lake bulk carriers and that there was little to be gained by increasing this speed, in fact, the additional power required would be more likely to show a financial loss in operation. Whereas the length of voyage of the vessels in the limestone trade was only 450 miles, the length of voyage of the ore boats is from 950 to 970 miles and additional cargoes could be carried only at the expense of some 55 to 60 percent extra horsepower. He emphasized the advantage of the reduced fire-room force on the *Bradley*.

The Central Power Station Goes to Sea

By Commander Q. B. Newman, U. S. C. G.

An abstract of this paper will be published in an early issue.

Discussion

W. L. R. EMMET stated that he began talking before the society 20 years ago about the advantages of electrically-driven ships and he pointed with pride to the development of electric drive in the Navy, culminating in the record just made by the airplane carrier *Lexington* in attaining a speed of 34.5 knots with machinery developing 210,000 horsepower, and to the installations of electric drive that are now being made in merchant ships. From the first he had advocated the advantages of regenerative feed heating and the driving of auxiliaries from the main units.

DR. E. MULLER pointed out that while the Germans are not in favor of electric drive they are rapidly adopting the Bauer-Wach system in which an exhaust-steam turbine is combined through gearing with a reciprocating engine resulting in an increase of 35 percent in power without adding to the fuel consumption or a saving of from 20 to 25 percent in fuel if the speed of the vessel is not increased. Within 22 months 105 vessels of 864,400 tons deadweight and 435,000 indicated horsepower equipped with this system have been placed in operation or are under construction.

REAR ADMIRAL C. W. DYSON said that he designed the propellers for the *Bradley* and for the Coast Guard cutters. Trial data were available from six ships on Lake Erie. The power loss factor in Lake Erie was 0.954 and in Lake Michigan (deep water) 1.12, which is the normal factor for this type of ship. He recalled that the percentage of backing power was never talked of until direct turbine drive came in. The battleship *Delaware* (reciprocating engines) was stopped from full speed ahead in 1 minute 30 seconds while the *Utah* (turbine drive) was stopped in 3 minutes 30 seconds. The amount of backing power depends upon the ability of the engines to stand the strain upon the shaft and upon the lines of the stern.

J. E. BURKHARDT: In these days there are many opinions and much discussion as to the most suitable type of propelling machinery; and an expected gain of 10 or 15 percent in fuel is often sufficient to cause the selection of a particular type of machinery over all others. Here are two comparable vessels both with turbo-electric drive, both with Babcock & Wilcox water-tube boilers yet for the later vessel the fuel consumption at full speed has been cut almost in two. This surely is worth some study.

We have made a very careful analysis of the data presented in both papers. We have used runs No. 2 and No. 5 of the *Pontchartrain* for comparison with runs No. 5 and 8 of the *Modoc*, because the data from these *Pontchartrain* runs more readily lends itself to analysis. The actual gain in economy under normal conditions will be slightly greater than is here stated, because of feed heating by bleeder steam. We have adjusted the oil consumption to the same heat value of the fuel, and the shaft horsepower to the same speed. The following results were obtained:

	Individual gain, percent		Contribution to total gain, percent	
Speed	16.15K	12.5K	16.15K	12.5K
1. Reduction in S.H.P. per ton, due to better lines, fairing of appendages and use of contra-propeller	18.1	5.4	14.7	4.7
2. Increased boiler efficiency	3.1	3.3	2.5	2.9
3. Increased heat available to main turbines, due to higher pressure and temperature and better vacuum	10.8	6.9	8.8	6.0
4. Increased conversion efficiency of combined propulsion unit (turbine, generator and motor)	10.7	4.0	8.7	3.5
5. Improvement in auxiliaries	10.8	20.1	8.8	17.5
Totals			43.5	34.6

The order in which the items are listed is arbitrary. Any one or any combination of these gains could probably have been realized separately except that item 4 is related somewhat to item 3. The columns marked "Individual Gains," show the gain due to each item considered independently. The true gain is less than the sum of these since each succeeding gain after the first is a percentage of a smaller base. The columns marked "Contribution to Total Gain," are obtained by apportioning the total gain in proportion to the individual gains.

It should be noted particularly that no part of this great improvement has been due to any change in type of propelling machinery. This is a striking example of what can be accomplished by going after every possible gain.

ADMIRAL R. S. GRIFFIN: In analyzing the figures in the paper, it is by no means easy to determine how much of the superiority of the *Pontchartrain's* performance is due to the higher steam pressure and superheat and to electrification of the auxiliaries, because there are many points of difference between the two installations. The improvement in the *Pontchartrain* is very marked, due in large measure, I think, to the great reduction that has been made in the consumption of power for excitation. At full power in the *Modoc* nearly 10 percent of the total steam was used for excitation while in the *Pontchartrain* only a little more than 3.5 percent of the total steam was used for this purpose. At ¾ speed, the figures were respectively 17.8 and 8.0 percent of the total steam.

The boilers of both vessels are almost identical with respect to combined heating and superheating surfaces. The boilers on the *Pontchartrain* have less heating surface but greater superheating surface than those of the *Modoc*, and the design to provide for this has resulted in an increase of about 18 percent in the furnace volume of the *Pontchartrain* over that of the *Modoc*, and this naturally contributes something to economy.

There is entirely different design of main turbine, and while I would not venture to say that the turbine of the *Pontchartrain* is more economical than that of the *Modoc*, the figures would seem to justify such a conclusion. Here again, there is another consideration than that of high pressure and superheat to be considered, and that is the superior vacuum. The water rate of the *Pontchartrain's* turbine at full power was only 75 percent of that of the *Modoc*, and at ¾ speed only 76.3 percent, but the determination of how much the better vacuum of the

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Pontchartrain may have contributed to this result I shall leave to others.

Because of the differences to which I have alluded, it seems impossible to reach a definite conclusion regarding the portion of the general economy which may be attributed to electrification of the auxiliaries, but the figures given in Plate 7 leave no doubt that economy has been effected.

W. W. SMITH: On page 1, it is stated that the *Pontchartrain* is fitted with a contra-propeller, and on plate 2 the propulsive efficiency is found to be from 55 to 60 percent. This is unusually low for a single-screw contra-propeller, for which the efficiency is seldom less than 65 percent.

Why were the feed pumps, or at least one of them, not motor driven?

Referring to the excellent test data, it would be desirable to include in these data, and in all test data of this kind, absolute values which do not vary with the kind of fuel and its heat contents.

The water rate of the turbine is not a measure of its efficiency. It is desirable to state the turbine efficiency: an absolute value independent of the heat range, which is generally comparable. It is also desirable to give the heat consumption as an absolute value.

Referring to plate 6, item 31, what is the motor efficiency, and what losses are included, and not included? Was the motor efficiency measured by test, or was it estimated completely, or in part? Was the S.H.P. measured, or was it determined from electric instruments, and if so, were the errors measured and corrected? These data are necessary to substantiate the values given.

On *Pontchartrain* run No. 1, with the auxiliary turbine furnishing power to the auxiliaries, the ful consumption was 0.89 pound per shaft horsepower. On run No. 2 under the same conditions, except that the main turbine furnished power to the auxiliaries, the fuel consumption was 0.823 pound. Thus, the fuel consumption was 8 percent greater with the auxiliary turbine supplying the auxiliaries. With ordinary steam auxiliaries, it is estimated that the fuel consumption is about 20 percent greater than for electric auxiliaries supplied by the main turbine. Thus it is evident that electric auxiliaries supplied from the main turbine are much more efficient, and are a highly desirable feature which should be used with turbine machinery of both electric and gear-drive types.

On run No. 2, with no steam bled from the main turbine, the fuel consumption was 0.84 pound per shaft horsepower. On run No. 3 under the same conditions, except that steam was bled from the main turbine for feed heating, the fuel consumption was 0.823 pound Thus, the fuel consumption without bleeding was 2 percent greater. In this installation, there is only one feed heater, part of the steam comes from the feed pump, and the feed temperature is around 200 degrees. With two or three stages, complete bleeding, and high feed temperature, the increase without bleeding would be around 5 percent. Thus, bleeding the turbine is well worth while, and is a feature which should be used in high efficiency installations.

W. E. THAU: The paper emphasizes three distinct methods by which ships can be operated with a net reduction in fuel cost:

1. The use of electric in place of steam-driven auxiliaries.

2. The use of the central station idea for driving the propeller and the auxiliaries from a common prime mover, made practicable by the dual drive system.

3. The bleeding of the main turbine for feed heating as a substitution for the old idea of auxiliary exhaust.

Discussing these three factors in the order given, we have:

Electric-driven, engine-room auxiliaries supplied with power from an isolated turbine generator plant can be operated on at least one-half to one-third the amount of steam consumed by comparable steam-driven auxiliaries. The net reduction in total steam, and hence fuel, and boiler capacity, amounts to from approximately 10 to 20 percent which, when equated to carrying charges, more than justifies the electric auxiliary system. The use of electric engine-room auxiliaries eliminates a large amount of steam and exhaust piping, and results in a cleaner and cooler engine room, all of which are conducive to better maintenance.

2. The saving in fuel consumption effected by the central station idea of supplying the auxiliaries direct from the main generator instead of from the isolated generating plant amounts to 7½ percent, a figure which speaks for itself, particularly when it is realized that the dual drive arrangement costs very little, if any, more than the isolated auxiliary generating plant considering the lesser cost of the alternating as compared with direct current auxiliaries.

3. It is now a proven fact that the use of an efficient electric auxiliary system in conjunction with bleeding the main turbine for feed heating is actual economy.

It is desirable to call attention to the fact that the system employed on the latest Coast Guard cutters is equally applicable to many types of cargo and passenger ships.

PROFESSOR EVERS BURTNER: As the steam conditions of the main turbine at full power for the *Pontchartrain* showed roughly an increase of 160 degrees F. superheat, an increase of 50 pounds per square inch in steam pressure and about 0.9 inch higher vacuum than the main turbine of the *Modoc,* there naturally will be a great reduction in steam consumption, in this case some 29 percent. If Commander Newman could advise us of the steam consumption correction factors based on steam consumption tests by the manufacturers for different steam conditions for this turbine the same would be of much interest. If approximate corrective factors to allow for the better steam conditions on the *Pontchartrain* are used, some 15 to 20 percent of the reduction in steam consumption can be explained. After making this correction for steam conditions the main turbine water rate of the *Pontchartrain* is still some 10 percent lower than the *Modoc.* This is due to the general refinement in design occurring in the last few years, to the greater power developed by the *Pontchartrain* unit and to the fact that the *Modoc* had seen 18 months' service before the test.

The gains in economy obtained by driving the auxiliaries by the main generator and through the use of bleeder heating can be determined by referring to the fuel consumption given in runs 1, 2, and 3 on Plate 6. Thus, operating the auxiliaries from the main generator results in about 5 to 9 percent saving in total fuel consumption.

Using bleeder heating at high power has reduced the fuel consumption still further. But at low power, test No. 6 using bleeder steam shows an increase in fuel consumption over test No. 5 instead of a decrease, due in this case probably to the fact that the full power nozzle group was not shut off as mentioned on page 5. Messrs. Fisher and Kennedy in their paper estimate the gain in economy (due to bleeder heating to about 160 degrees F.) as being 2.5 to 3 percent.

In the *Modoc* trials the auxiliary steam consumption of 32 percent of the total was high even for a low-

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powered, turbine-driven ship where 20 to 25 percent should be normal. The use of only 11 percent of the total steam for auxiliary operation is a notable improvement.

The method of driving the auxiliaries by the main turbo-generator helps to place the economy of an electric-drive propulsion system on a par with the full-power economy of an up-to-date geared-turbine installation. However, a very efficient geared-turbine system can be arranged with electric drive for all the auxiliaries that operate continuouslv, i.e. circulating pump, fuel-oil service pump, condensate pump, lubricating-oil pump, forced-draft blower, etc. High-economy, geared-turbo-generators with a water rate of about 17 pounds per kilowatt per hour at 250 kilowatts capacity are available which would be suitable for such an installation.

To illustrate the relative economy of the *Pontchartrain* and the *Bradley*, the following table comparing these ships with the *King George V* has been drawn up. It should be noted that the twin-screw, geared-turbine steamer *King George V* operates at a higher steam pressure and superheat. This advantage is counterbalanced by the use of steam auxiliaries, hand firing, etc.

The column showing the B.t.u. used per shaft horsepower per hour is the best measure of the relative economy.

Vessel	S.H.P.	Fuel	Fuel Lb./S.H.P./hr.	Efficiency ratio	B.T.U. per S.H.P./hr.
Pontchartrain Run No. 3.....	2845	Oil	0.823	0.54	15,280
Carl D. Bradley Test No. 2.....	4500	Coal	1.14	0.536*	15,490
King George V † Full power.....	3489	Coal	1.085	0.52	15,060

Notes: Efficiency Ratio Rankine Cycle $\frac{\text{Steam Consumption Main Turbine}}{\text{Total Steam/S.H.P./Hr.}}$

* Based on flow meter. Shaft horsepower determined from reported fuel consumption. Steam conditions at superheater nozzle, exhaust pressure 2 inches Hg.

† Reference London *Engineering*, January 21, 1927, page 89.

COMMANDER NEWMAN declared that any deficiency of data in the paper was due to the fact that the trials were completed only shortly before the meeting was held. The water rate was 16 pounds per brake horsepower at the turbine shaft. The machinery, which was purchased direct by the Coast Guard Service, cost $57.66 per horsepower or a total of $173,000 per ship.

Description and Trials of the S. S. California

By Roger Williams*

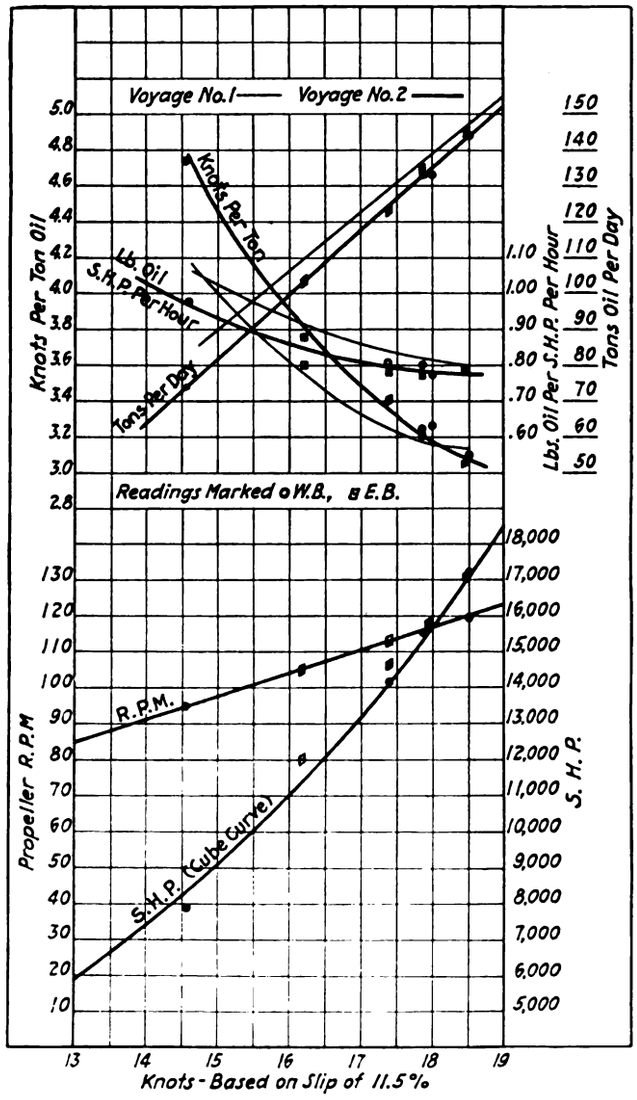
ABSTRACT

As the *California* was fully illustrated and described in the February, 1928 issue of MARINE ENGINEERING AND SHIPPING AGE, only the latter part of this paper, dealing with the trials and performance of the vessel in service, is included in this abstract.

During Christmas week, 1927, the ship was drydocked and painted. Inclining tests were made while floating in the drydock. One week later, on January 7, 1928, the builders' trials were held outside Cape Henry. These trials were completed in one day, the ship leaving the yard at daylight and returning shortly after sundown. Runs were made between the Cape Henry sea buoy and False Cape buoy, a distance of 16⅝ miles. Two runs were made with one generator connected with both motors, and two runs with both generators connected, using enough power to give full speed. The mean depth of water on this course is 58 feet and the ship was ballasted to 24 feet draft.

* Manager, Operating Department, International Mercantile Marine Company.

The trials were a pleasant experience. The weather conditions were perfect. The performance of the machinery was excellent in all particulars. The most noticeable features of the trials were the complete absence of vibration in all parts of the ship and the excellent maneuvering qualities. The speeds attained were 13.6 knots using one generator and 18 knots using both



Characteristic performance curves, S.S. California

Average draft, west bound, 25 feet 3 inches; east bound, 29 feet 6 inches; total oil consumption, round voyage, including port consumption at New York, 3821 tons.

generators. Owing to the shallow water, no attempt was made to exceed the contract requirements and owing to the shortness of the runs, a close check on fuel expenditure was not practicable, although a very fair indication was given that the fuel efficiency was well within the expectations of the owners. No attempt at fuel economy was made; all boilers were in use except on the last run, when two were cut out.

The following data were obtained:

FULL POWER RUNS—AVERAGE RESULTS

					Motor			
Run No.	Revs.	Dist.	Speed	Slip	K.W.	Loss	S.H.P.	Eff.
1	119.1	16⅝	18.09	13.3	13,200	240	17,350	98.2
2	118.9	16⅝	17.91	14.0	13,100	243	17,200	98.1
Average ...	119	....	18.00	13.65	.....	...	17,275	...

	Generator						
	K.W.	Loss	S.H.P.	Eff.	Field loss	Vent loss	Overall eff.
1	13,200	347	18,150	97.4	143	45	94.2
2	13,100	347	18,000	95.4	143	45	94.2
Average ...	.....	...	18,075	...	...	...	94.3

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Table I.—Performance Data of S. S. California, Voyage No. 2, New York to San Francisco and Return

Bound	From Pilot Station to Pilot Station	1928 Date	Time elaps. Hrs.:Min.	Distance by observ. N. Mi.	Speed K	P.&S.	Avg. R.P.M.	App. Slip %	Motor: Amps.	Motor: K.W.	Motor: Loss K.W.	Motor: S.H.P.	Motor: Eff. %	Generator: Amps.	Generator: K.W.	Generator: Loss K.W.	Generator: B.H.P.	Generator: Eff. %	S.H.P. B.H.P.	Field Loss: Amps. Volts	Field Loss: Amps. Motor	Field Loss: Amps. Gen.	Field Loss: K.W.	Vent Loss K.W.	O.A. Eff. %
1—West		3-10				P.	114.72		885	6060	109	7970		885	6060	159	8330			120	337	243			
	New York	3-13	69:56	1166		S.	115.35		847	5982	107	7870		847	5982	160	8220			120	337	249			
	to				16.68	Avg.	115.04	17.25	866				98.2	866				97.4	95.7	120					94.3
	Havana					Total				12042	216	15840			12042	319	16550				674	492	140	45	
2—East		4-13				P.	115.16		875	6300	108	8290		875	6300	160	8650			120	349	255			
	Havana	4-16	62:04	1172		S.	115.69		871	6076	108	8000		871	6076	162	8350			120	343	254			
	to				18.88	Avg.	115.42	6.63	873				98.3	873				97.5	95.8	120					94.4
	New York					Total				12376	216	16290			12376	322	17000				692	509	144	45	
3—West		3-13				P.	111.7		807	5392	99	7100		807	5392	148	7280			120	328	240			
	Havana	3-16	58:45	1003		S.	112.6		786	5282	98	6940		786	5282	151	7430			120	325	240			
	to				17.07	Avg.	112.2	13.11	796				98.2	796				97.3	95.5	120					94.0
	Colon					Total				10674	197	14040			10674	299	14710				653	480	136	41	
4—East		4-10				P.	105.3*		711	4640	85	6110		711	4640	127	6380			120	330	244			
	Colon	4-13	61:35	1007		S.	105.45		715	4592	85	6040		715	4592	127	6320			120	329	249			
	to				16.35	Avg.	105.4	11.43	713				98.2	713				97.3	95.5	120					93.8
	Havana					Total				9232	170	12150			9232	254	12700				659	493	138	40	
5—West		3-16				P.	116.0		868	6136	108	8080		868	6136	162	8150			120	335	247			
	Balboa	3-23	162:19	2827		S.	116.4		865	5914	108	7770		865	5914	164	8440			120	330	241			
	to				17.42	Avg.	116.2	14.5	867				98.2	867				97.4	95.6	120					94.2
	San Diego					Total				12050	216	15850			12050	326	16590				665	488	138	45	
6—East		4-2				P.	112.4		815	5676	100	7470		815	5676	150	7810			120	336	247			
	San Pedro	4-9	169:34	2907		S.	112.6		808	5492	100	7230		808	5492	150	7570			120	334	244			
	to				17.13	Avg.	112.5	13.0	812				98.2	812				97.4	95.6	120					94.1
	Balboa					Total				11168	200	14700			11168	300	15380				670	491	139	42	
7—West		3-25				P.	118.7		950	6550	119	8620		950	6550	173	9010			120	346	250			
	San Pedro	3 26	19:13	353		S.	120.0		950	6500	120	8550		950	6500	177	8950			120	348	247			
	to				18.35	Avg.	119.35	12.25	950				98.2	950				97.4	95.6	120					94.3
	'Frisco					Total				13050	239	17170			13050	350	17960				694	497	143	45	
8—East		3-31				P.	117.5		912	6525	114	8590		912	6525	168	8970			120	350	255			
	'Frisco	4-1	19:09	353		S.	118.5		912	6500	115	8560		912	6500	171	8940			120	350	250			
	to				18.43	Avg.	118.0	10.8	912				98.2	912				97.5	95.7	120					94.4
	San Pedro					Total				13025	229	17150			13025	339	.17910				700	505	145	45	

Bound	P. & S.	Running time, hrs.	No. boilers in use	Steam at boilers: Press.	Steam at boilers: Temp.	Steam at boilers: Sup.	Main stm., press.	Nozzles open	Steam at H.P. chest: Press.	Steam at H.P. chest: Temp.	Steam at H.P. chest: Sup.	Drop boilers to H.P. chest: Press.	Drop boilers to H.P. chest: Temp.	Drop boilers to H.P. chest: Sup.	H.P. 1st stg., press.	Bleed. stm., press.	Main exh., temp.	Vac. at cond.,* ins.	Cooling water: Inj. temp.	Cooling water: Disch. temp.	Temp. rise, deg. F.	F. & F. tank, temp.	Main feed, 1st st., 2nd st., temp.	Mean displacement	Speed in knots	Fuel consumption: Tons	Fuel consumption: Lbs./S.H.P./Hr.	Fuel consumption: Lbs./100 K.	Fuel consumption: Tons/Day
1—West	P.						255	21-22	251	503	97	19	7	0	83	½	96	28½		81	13								
	S.						255	21-22	253	502	95	17	8	2	83	5	94	28½		83	15								
	Avg.	69.93	10	270	510	97	255	21-22	252	502	96	18	8	1	83	2½	95	28½	68	82	14	111	{192 233	24200	16.68	386	.779	74200	132.7
2—East	P.						255	22	254	512	104	16	3	—2	91	1	98	28½		75	8		{196						
	S.						255	22	255	515	107	15	0	—5	89	3	93	28¾		76	9		{235						
	Avg.	62.07	10	270	515	102	255	22	254	513	105	16	2	—3	90	2	95	28½	67	75	8	115	{194 234	24750	18.88	347	.769	66300	134.1
3—West	P.						255	18-22	250	505	99	20	0	—7	75	8	98	28½		89	10								
	S.						255	18-22	250	498	92	20	7	0	77	6	98	28½		90	11		{192						
	Avg.	58.75	10	270	505	92	255	18-22	250	501	95	20	4	—3	76	3	98	28½	79	89	10	120	{235	24150	17.07	300	.814	67000	122.5
4—East	P.						255	18	230	499	100	40	10	—4	66	2	99	28½		88	9		{189						
	S.						255	18	229	500	101	41	9	—5	64	9	95	28½		88	9		{235						
	Avg.	61.58	9	270	509	96	255	18	229	499	100	41	10	—4	65	5½	97	28½	79	88	9	125	{190 235	28100	16.35	266	.795	59100	103.6
5—West	P.						255	22-23	254	511	103	16	0	—5	88	1	99	28¼		86	10								
	S.						255	22-23	255	505	97	15	6	—1	88	5	97	28½		86	10		{196						
	Avg.	162.3	10	270	511	98	255	22-23	254	508	100	16	3	—2	88	3	98	28½	76	86	10	118	{233	23150	17.42	897	.781	71000	132.8
6—East	P.						255	18-22	253	501	94	17	5	—1	81	1	99	28½		86	10		{195						
	S.						255	18-22	253	505	98	17	1	—5	79	5	97	28½		87	11		{235						
	Avg.	169.6	9&10	270	506	93	255	18-22	253	503	96	17	3	—3	80	3	98	28½	76	86	10	120	{195 234	29500	17.13	868	.780	66900	123.0
7—West	P.						255	22	253	521	114	17	—1	—7	89	1½	90	29		70	14								
	S.						255	22	253	512	105	17	8	—2	93	3	85	29		70	14		{191						
	Avg.	19.22	10	269	520	107	255	22	253	516	109	17	4	—2	91	2	87	29	56	70	14	105	{230	23100	18.35	115	.780	73008	143.4
8—East	P.						255	22	254	513	106	16	4	—2	92	1½	92	28¾		71	18		{191						
	S.						255	22	254	513	106	16	4	—2	93	3	88	29		72	19		{229						
	Avg.	19.15	10	270	517	104	255	22	254	513	106	16	4	—2	92	2	90	28¾	53	71	18	106	{191 229	27400	18.43	115	.784	72900	144.2

* Vacuum at condenser by vacuum gage.

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Delivery was effected January 13, 1928. The owners' crew took the ship out on the following day and proceeded to New York. On the run north full speed was made between Cape Charles Lightvessel and Winter Quarters, a distance of 62 miles, the ship averaging 19 knots; average depth, 82 feet.

First Voyage

On January 28, 1928, the ship sailed from New York with a capacity list of passengers on her first voyage. She left in a northeast blizzard and encountered a gale outside which lasted for the first day. Her steadiness and absence from vibration and absence of propeller racing produced a very favorable impression on her passengers. The voyage to San Francisco and return was made without a hitch, and, while no particular effort was made at this time to economize in fuel, we were pleased to note an average consumption of 0.8 pound per shaft horsepower for all purposes, and the ability to make 18½ knots when fully loaded to her 32-foot draft and when the temperature of the sea water was about 80 degrees.

We were pleased to note a low consumption of fresh water. This is a matter of concern in a ship where hot and cold fresh water is provided in the staterooms without limit. The economy in this case is due to the use of so much electric machinery, where the absence of gland losses reduces the quantity of make-up boiler feed water.

The economy in lubricating oil is also gratifying, and it is expected that the oil originally supplied the forced lubrication system will last many years.

Second Voyage

The performance data for voyage No. 2 is given in Table 1 as being representative of what can be expected in continued service. An improvement over voyage No. 1 is noted, the fuel consumption being reduced to 0.77 pound per shaft horsepower for all purposes, which we consider quite good in view of the heavy refrigerating load and large passenger demands.

The results are tabulated from data taken from the engineer's logs.

Discussion

Captain C. A. McAllister: The *California*, having the first large installation of electric drive on a merchant vessel, marks a decided step forward in marine engineering. This system of drive has already demonstrated high efficiency and substantial promise of ultimate reliability and unquestionably has now become a robust contender with other recognized methods of driving merchant vessels. Its adaptability for naval and other governmental types of ships has already been proven to the satisfaction of all concerned. The only thing lacking in the paper, and admittedly one quite difficult upon which to make a fair conclusion, would be a statement as to relative costs of construction with other types. The great steaming radius provided will be decidedly advantageous if the *California* is ever needed as a naval auxiliary or transport.

H. L. Ferguson: There are several features in the design of the *California* which appeal to me strongly. Electric drive gives a control in operation of the vessel superior, I believe, to any other. There is an absence of vibration even in heavy weather. Initial cost is greater but maintenance charges should be less and length of life greater. The machinery layout is such as to provide ample room and accessibility allowing for proper care and repair at minimum cost.

The experience of the owners in the operation of large passenger ships made it possible for us in the development of the design to receive information and direction from them of the best possible character in working out the hundreds of essential details. It took about twenty-seven months to build the *California*. A second vessel now nearing completion will require only seventeen months, a third now under construction will not take longer. The representatives of the owners, under Captain Williams, have determined what they actually require for their service and have worked with the builders in reaching these requirements. The result is inevitably a better ship at less cost and quicker completion than can be had otherwise. The lesson is obvious. Design of ships of this character is the chief factor in cost, and is vastly more important than any possible savings in labor or material.

E. H. Rigg: One of the chief points discussed in the design stage was the stability; she was designed for rather more metacentric height than has up to now been considered proper. Her steadiness at sea has been commented on favorably by passengers as well as by owners.

The excellent subdivision of the ship is worthy of note. She is big enough to be well protected in this respect and the owners are to be congratulated on their facing of the problem of shorter holds in the interests of their passengers' safety. Captain Williams says she complies with the 1914 convention; may I say she does better, she is a full two-compartment ship.

W. W. Smith: The arrangement of the main and auxiliary turbines and condensers follows power-plant practice with the condensers under the turbines, which is very desirable. The use of electric auxiliaries is a very important feature, which accounts in considerable part for the low fuel consumption. Two-stage feed heating with steam bled from the main turbine materially reduces the fuel consumption.

Referring to plate 3, the fuel-rate curve is not as flat as it should be as shown by the following table:

Speed Fraction	Speed, Knots	Fuel Rate	Fuel-rate Fraction
1.0	18.0	0.78	1.00
0.9	16.2	0.85	1.09
0.8	14.4	0.98	1.26
0.7	12.6	1.18	1.51

Referring the fuel rate to that at the designed speed of 18 knots, it is seen that the fuel rate at 90 percent speed is 9 percent greater; at 80 percent it is 26 percent greater; and at 70 percent it is 51 percent greater. Thus, it is evident that the fuel rate increases rapidly with reduction in speed, which is undesirable.

Referring to page 8, and to plate 1, the efficiencies given for the main generator and motor are too high to pass without question as to what they represent, and how they were measured.

Referring to page 8, and plate 2, what was the heat content of the fuel? It is desirable to give the heat consumption as an absolute value. For example, with a fuel consumption of 0.78 pound per shaft horsepower, and assuming 18,500 B.t.u. oil, the heat consumption would be 14,400 B.t.u. per shaft horsepower, which would be comparable with 15,400 B.t.u. for the *Bradley*.

The data do not include the readings of integrating meters for main and auxiliary power as given in Mr. Fisher's paper. These readings are very important, and it would be desirable to have them in all cases where electric power is used, for the reason that integration by instrument is much more accurate than approximate integration from log readings.

Captain Roger Williams stated that the *California* has completed seven voyages, traveling 80,000 miles with no electrical troubles; the fuel consumption remains the same as on voyage No. 2, namely, 0.77 pound per shaft horsepower.

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Turbo-Electric Drive on Great Lakes*

Details of propelling machinery and trial and service tests on self-unloading freighters

By C. R. Fisher† and A. Kennedy, Jr.††

THE cost of operating ships on the Great Lakes has very materially increased in the past ten or fifteen years, due primarily to increases in fixed charges, wages of crew and licensed officers, provisions and fuel. In an endeavor to meet these increased costs of operation the ship operators have built larger ships, endeavoring in this way to reduce the fixed charges, wages of crew and licensed officers, and provisions on a tonnage basis. There are practical limits in size of ships for a given service due to limited docking facilities, drafts, etc., and undoubtedly modifications will be made in the design of new ships as these various limitations change.

There have been some endeavors to decrease the cost of fuel, but until very recently such endeavors have been of a minor nature. The reciprocating-steam-engine ship on the Great Lakes today takes between 1.65 and 2.25 pounds of coal per shaft horsepower hour for all purposes under a steady steaming condition. The coal used when the ship is delayed, checked, loading and unloading will materially increase the coal per shaft horsepower hour for all purposes.

The operating conditions on the Great Lakes are quite different from sea conditions. The average length of trip is relatively short; cargoes are often transported in one direction. Tugs are rarely used. The cost of coal when compared with the cost of Diesel oil on a pound basis is something in the ratio of one to three; that is, slacked coal costs approximately two-tenths of a cent per pound, whereas Diesel oil costs approximately six-tenths of a cent per pound. This is one reason why coal is used on the average Great Lakes cargo ship. There are special ships and services where oil can be economically used on the Great Lakes.

The Bradley Transportation Company has for the past six or eight years closely followed modern forms of drive, especially with reference to reliability, adaptability to their particular service, maintenance and economy. In 1924, after studying the various types of drive, they decided to install a turbine-electric drive on the *T. W. Robinson,* which was at that time being built by the American Shipbuilding Company. The arrangement of the apparatus is not ideal, as the engine room had been laid out for a reciprocating steam engine.

In 1925 the Bradley Transportation Company decided to build the largest cargo ship on the Great Lakes and specified turbine-electric drive. This ship was laid out for electric drive and is equipped with stokers, watertube boilers, superheaters, air preheaters and a main turbine generator which furnishes all of the power for propelling and for the various electrical auxiliaries.

Details of the Carl D. Bradley

(General Information)

Service—Limestone carrier.

Shipbuilder—American Shipbuilding Company, Cleveland, Ohio.

Propelling machinery builder—General Electric Company, Schenectady, N. Y.

Owner—Bradley Transportation Company, Rogers City, Michigan.

(General Dimensions)

Length overall	638 feet	8 inches
Length between perpendiculars	615 feet	0 inches
Molded breadth	65 feet	0 inches
Molded depth	33 feet	0 inches
Movable structural steel boom (length)	160 feet	0 inches
Discharge belt conveyor (width)		60 inches

(Tonnage)

Weight of hull—7160 short tons (water in boilers and no fuel).
Displacement—Loaded to 20-foot draft, 21,700 short tons.
Loaded to 22-foot 6-inch draft, 24,600 short tons.
Weight of boiler-room equipment without water, 305 short tons.

(Boilers)

Number, 2.
Type, watertube. Equipped with automatic stokers.

Total heating surface square feet	5630	(each boiler)
Total grate surface, square feet	100	(each boiler)
Superheater surface, square feet	1340	(each boiler)
Water wall surface, square feet	52	(each boiler)
Superheat, degrees Fahrenheit	278	
Working pressure, pounds per square inch	325	

(Engine)

Number, 1.
Type, turbine generator with direct-connected exciter.
Capacity, 5600 kv.a., 2300 volt and 75/65 kilowatts, 120-volt exciter.

(Propelling Motor)

Number, 1.
Type, Form M induction.
Capacity, 4800 shaft horsepower.
Revolutions, 104.5.

(Propulsion Control)

Manually-operated air-break contactors with turbine-speed-control lever and water-cooled resistor.

(Propeller)

Number, 1.
Type, 4-blade sectional.
Revolutions per minute maximum, 104.5.
Projected area, square feet, 79.23.
Developed area, square feet, 89.12.
Disc area, square feet, 203.69.

(Condenser Apparatus)

Type, surface.
Square feet, 4600.
Air pumps, Radojet.
Vacuum, 1½ inches, absolute.

(Electric Auxiliary Apparatus)

One 75/60 kw., 3600/2700 r.p.m., 120 volt, direct-connected d-c. generator to the main propelling generator.
One dual-drive set consisting of one 250 kw. 1200/840, 120/240 volt, d-c. generator direct connected to one 750/520 kv.a., 1200/840 r.p.m. synchronous motor-generator direct connected to one turbine operating at 300 lbs., 700 deg. total temperature, condensing or non-condensing.
One 20 h.p., 1800 r.p.m. motor-driven condensation pump, driven by means of a squirrel-cage induction motor.
One 10 h.p., 1800 r.p.m. mate's pump, driven by means of a squirrel-cage induction motor.
One 40 h.p., 1800 r.p.m. general service pump, driven by means of a squirrel-cage induction motor.
Two auxiliary ballast pumps, each driven by a 20 h.p., 1200 r.p.m. squirrel-cage induction motor.
One ash sump pump, driven by means of a 50 h.p. slip-ring induction motor.
One oil cooler pump, driven by means of a 10 h.p., 720 r.p.m. slip-ring induction motor.
One bilge pump, driven by means of a 7½ h.p., 1200 r.p.m. squirrel-cage induction motor.
Two sump pumps, each driven by means of a 25 h.p., 900 r.p.m. slip-ring induction motor.
Two vacuum pumps, each driven by means of a 15 h.p., 600 r.p.m. squirrel-cage induction motor.
One circulating water pump, driven by means of a 75 h.p., 600 r.p.m. slip-ring induction motor.
One anchor windlass, driven by means of a 55 h.p., 625 r.p.m., d-c. motor.
Four forward and center mooring winches, each driven by means of a 35 h.p., 600 r.p.m., d-c. motor.

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* Abstract of a paper presented at the thirty-sixth general meeting of the Society of Naval Architects and Marine Engineers, held in New York city, November 15 and 16.

† Electrical Engineer of the Bradley Transportation Company, Rogers City, Mich.

†† Federal and marine department of General Electric Company, Schenectady, N. Y.

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Two center deck-hatch winches, each driven by means of a 10 h.p., 675 r.p.m., d-c. motor.
Twenty-two ventilating fans.
One induced-draft fan, driven by means of a 40 h.p., slip-ring induction motor.
Two forced-draft fans, driven by means of a 30 h.p., slip-ring induction motor.
Three transformers, each rated 200 kv.a., 2300/230/115 volts.
One storage battery, 400 ampere hour, 120 volt.
One gasoline set rated 5 kw., 110 volts.
One oil centrifuge.
One drinking water pump driven by means of a one h.p., 110 volt, d-c. motor.
One electric galley equipment consisting of one 4.2 kw. bake oven, one 4 kw. coffee urn, one 22 kw. range.
One washing machine.
One boiler-feed pump, driven by means of a 100 h.p., 1800 r.p.m. slip-ring induction motor.
One ventilating fan for main propulsion motor, driven by means of a 40 h.p. squirrel-cage induction motor.
One air compressor, driven by means of a 10 h.p., 720 r.p.m. squirrel-cage induction motor.
One arc welder, driven by means of a 7½ h.p., 1750 r.p.m., d-c. motor.
One refrigerating machine, driven by means of a 5 h.p., squirrel-cage induction motor.
One oil pump for damper regulator, driven by means of a ¼ h.p. induction motor.
Two coal-feeder belts, each driven by a 10 h.p., 600 r.p.m., slip-ring induction motor.
Flow meters—integrating and recording flow meters have been installed to measure total steam flow to the main turbine, auxiliary steam, steam from each boiler and the water to the boilers.
One radio set, 2 kw.
All of the auxiliaries, with the exception of the fresh water pump and oil purifier, are driven by alternating current induction motors. Power for these auxiliaries is furnished from the main propelling generator

(AUXILIARY STEAM APPARATUS)

One steering engine; size, 9 inches by 9 inches.
Two aft deck winches; size 9 inches by 10 inches.

(STAND-BY STEAM UNITS)

One reciprocating boiler feed pump, 10 inches by 7 inches by 18 inches.
One 75 h.p., 3500 r.p.m. steam-turbine-driven boiler feed pump.
One 15 h.p., 1430 r.p.m. steam-turbine-driven condensate pump.

General Description

Steam for propulsion and for auxiliaries is furnished by two watertube boilers equipped with water walls, superheaters, air preheaters and stokers. The compact arrangement of using convection-type superheaters, tubular air preheaters with vertical headers located on top of the boilers was suggested by W. W. Smith, chief engineer of the Federal Shipbuilding Company, who has been of great assistance on the problems arising in connection with this ship.

Slacked coal is taken from the coal bunkers by means of motor-operated belt conveyors to the hoppers. The boiler-room crew has been reduced from three men per watch to one man per watch, with a net saving of six men in the boiler room.

All power for propulsion and for driving the electrically driven auxiliaries is normally furnished by one steam turbine direct connected to a three-phase, alternating-current generator and a direct-connected, auxiliary, direct-current generator. The propulsion-control equipment consists of a steel panel on which the various electrical instruments are mounted and the levers for varying the turbine speed and manually operating air-break contactors which make the necessary connections between the main alternating-current generator, the propulsion motor and the water-cooled resistor.

The various auxiliary alternating-current motors have their starters with disconnecting switches made up in the form of a switchboard, and in this way they are accessible, easily inspected and located convenient to the operator. The various starting switches are located at the motors.

Auxiliary Power

Until quite recently, auxiliary power for driving electrically-driven auxiliaries was obtained from separately driven turbine generators. The efficiencies of relatively small turbines are not at all satisfactory when compared with the efficiencies of the larger main unit. When the layout of the *T. W. Robinson* was made, the installation of a motor-generator set for obtaining auxiliary power from the main unit was considered, but due to the limited time and for operating reasons, it was not installed. Operating experience showed, however, that the installation of this motor generator set would be an improvemennt.

Later a 250-kilowatt direct-current generator, driven by means of a 750-kilovolt-ampere, synchronous motor was installed on the *T. W. Robinson*.

The *Carl D. Bradley* has gone a step further by taking the auxiliary power from the main generator and from a direct-connected, direct-current generator.

It is necessary to have a stand-by for the direct-connected, direct-current generator, and when loading and unloading, there is a relatively large amount of direct-current power required for the deck machinery. It was therefore decided, in addition to the direct-connected auxiliary generator, that a motor-generator set would be installed having a turbine direct connected to this motor-generator set. This is commonly called a "dual drive set," as it may be driven by means of the alternating-current motor or by the steam turbine, using under this condition the alternating-current motor as an alternating-current generator.

Under normal operating conditions a Great Lakes ship is operated at or above three-quarters speed, except when maneuvering. If it is desired to reduce the propeller speed below three-quarters speed, this is normally done on the *Carl D. Bradley* by inserting a resistor in the propulsion-motor rotor circuit. The resistor has several steps so that several different speeds may be obtained, the lowest speed being approximately twenty-five to thirty revolutions.

Operating Tests

From September 29 to October 1, 1927, tests were conducted between Calcite, Mich., and Buffington, Ind., and between Buffington and Calcite on the *Carl D. Bradley*.

The tests consisted of weighing the coal and measuring steam and water by means of flowmeters. The electrical output of the main propelling generator and input

TABLE 1.—TRIAL DATA TEST NO. 1
September 29, 1927—9 a. m. to 5 p. m.

Time	Direct connected D.C. generator kw.	Meter reading: Gen. kw. hrs.	Meter reading: Motor input kw. hrs.	A. C. volts	Propeller R.P.M.
Constant		1000	1000		
9:00	37.2	4180¾	3888½	2350	....
10:00	37.2	4184½	3892⅓	2350	104.5
11:00	37.2	4188½	3896	2375	102
12:00	37.2	4192½	3899.7	2400	103
1:00	42.0	4196	3903½	2450	101
2:00	38.4	4200+	3907	2400	103.5
3:00	40.8	4204	3911—	2400	103.5
4:00	38.4	4208	3914¾	2400	102.5
5:00	39.6	4212	3918	2400	102.5
Average ..	38.6	3900	3690	2398	103

TABLE 2.—TRIAL DATA TEST NO. 1

Time	Pres.	Temp. cond. °C.	Cir. water in °C.	Feed and filter °C.	Vacuum gage	Temp. S. °F. ther.	Steam °C. rec.
9:00....	310	36	12½	72	Shut D.	690	365
						691	367
10:00....	310	38	12	59	27.8	694	360
						684	368
11:00....	310	36	12	57	27.6	678	358
						690	368
12:00....	310	36	12½	68	27.9	687	355
						698	365
1:00....	310	35	12	64	27.7	690	360
						714	370
2:00....	310	36	12	62	27.7	680	362
						688	377
3:00....	310	37	12	80	27.7	692	358
						687	368
4:00....	310	36	13	84	27.7	692	360
						694	362
5:00....	310	36	13	68	27.6		365
							367

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A. S. M. E. Power Test Codes of 1923

Test No. 1.—Data and Results of Stationary Steam Boiler Test. Solid Fuels—As Fired—Dry

GENERAL INFORMATION

1	Date of test	September 29, 1927
2	Location	Str. Carl D. Bradley
3	Owner	Bradley Transportation Company
4	Maker and type of boiler	BT. W. Cross Drums
5	Maker and type of superheater	Interdeck Hairpins
6	Maker and type of water wall	Bailey
7	Maker and type of air heater	B. & W. Tubular
8	Maker and type of fuel-burning equipment	Westinghouse Stoker
9	Test conducted by	B. T. Co.
10	Object of test	To determine boiler efficiency

Description, Dimensions, Etc.

11	Boiler heating surface, two boilers	11,260 sq. ft.
12	Superheater surface	2,680 sq. ft.
13	Water wall surface	104 sq. ft.
14	Air heater surface	9,090 sq. ft.
15	Grate surface	200 sq. ft.
16	Fuel burning equipment	Underfeed stoker
17	Draft	Forced and induced
18	Fuel	Island Creek coal
19	Volume of combustion space	2220 cu. ft.
20	Furnace, center of grate to nearest heating surface	10 ft. 6 in.
21	Furnace volume per sq. ft. boiler heating surface	0.1975 cu. ft.

Fuel and Gas Analyses and Data

Fuel Proximate Analysis—Dry—As Fired

22	Volatile matter	percent	36.39
23	Fixed carbon	percent	56.65
24	Ash	percent	6.96
25	Moisture (as fired)	percent	3.9
26	Heating value per lb. (as fired)	B.t.u.	.....
27	Heating value per lb. (dry)	B.t.u.	14088
28	Fusion temperature of ash	deg. fahr.	2201
29	Size of coal as fired	Slack	.....

Fuel Ultimate Analysis

30	Carbon	percent	78.77
31	Hydrogen	percent	5.18
32	Oxygen	percent	6.34
33	Nitrogen	percent	1.29
34	Sulphur	percent	1.46
35	Ash	percent	6.96

Gas

36	Gas analysis, furnace: Percent CO_2—15.5; O_2—0.9; CO—1.1; N_2—82.5; SO_2—.....		
37	Gas analysis, boiler outlet: Percent CO_2—14.7; O_2—3.0; CO—0.6; N_2—81.7; SO_2—.....		
38	Gas analysis, economizer outlet: Percent CO_2—....; O_2—...; CO—...; N_2—....; SO_2—.....		
39	Gas analysis, air-heater outlet: Percent CO_2—11.8; O_2—6.8; CO—.15; N_2—81.25; SO_2—....		
40	Dry gas per lb. fuel, furnace (dry)	lb.	11.9
41	Dry gas per lb. fuel, boiler outlet (dry)	lb.	12.95
42	Dry gas per lb. fuel, economizer outlet (dry)	lb.	.....
43	Dry gas per lb. fuel, air-heater outlet (dry)	lb.	16.5
44	Dry gas per lb. fuel, theoretical (dry)	lb.	11.2
45	Air supplied per lb. fuel, furnace (dry)	lb.	11.44

Pressures and Drafts

46	Moisture in air	lb. per lb. air	.....
47	Steam pressure by gage, boiler	lb. per sq. in.	324
48	Steam pressure by gage, superheater outlet	lb. per sq. in.	314
49	Air pressure in ashpit zone, at burners	in. of water	.55
50	Draft in furnace	in. of water	.23
51	Draft at boiler outlet	in. of water	.....
52	Draft at economizer outlet	in. of water	.....
53	Draft at air-heater outlet	in. of water	1.23

Temperatures

54	Steam temperature	deg. fahr.	685
55	Moisture in steam	percent	.....
56	Superheat	deg. fahr.	259
57	Temperature of air surrounding boiler, (T_1)	deg. fahr.	86
58	Temperature of air entering air heater, (T_2)	deg. fahr.	91
59	Temperature of air leaving air heater, (T_3)	deg. fahr.	314
60	Temperature of air for combustion, (T_4)	deg. fahr.	314
61	Temperature of furnace, (T_5)	deg. fahr.	.....
62	Temperature of gases leaving boiler, (T_6)	deg. fahr.	554
63	Temperature of gases leaving economizer, (T_7)	deg. fahr.	.....
64	Temperature of gases leaving air heater, (T_8)	deg. fahr.	339
65	Temperature of feedwater entering boiler, (T_9)	deg. fahr.	158
66	Temperature of feedwater entering economizer, (T_{10})	deg. fahr.	.....
67	Temperature of water in boiler at point where gases leave boiler, (T_{11})	deg. fahr.	.....
68	Temperature of fuel, (T_{12})	deg. fahr.	86*

Hourly Quantities

69	Duration of test	hr.	8
70	Fuel as fired per hour	lb.	5556
71	Dry fuel per hour	lb.	5339
72	Fuel as fired per sq. ft. of grate per hour	lb.	27.8
73	Fuel as fired retort or per burner per hour	lb.	555
74	Dry fuel per sq. ft. of grate per hour	lb.	26.7
75	Dry fuel per retort or per burner per hour	lb.	533
76	Combustion space per lb. coal per hour (as fired, dry)	cu. ft.	.416
77	Refuse per hour	lb.	414
78	Actual water per hour	lb.	48129
79	Factor of evaporation	lb.	
80	Equivalent evaporation per hour	lb.	60449
81	Units of evaporation	U.E.	58659
	(a) Boiler horsepower, average	hp.	1752

Refuse

82	Refuse, percent of fuel (dry)	percent	7.7
83	Percentage of combustible in refuse	percent	10.28
84	Carbon burned per lb. fuel (dry)	lb.	.78

Evaporation

85	Actual evaporation per lb. fuel (dry)	lb.	9
86	Equivalent evaporation per lb. fuel (as fired)	lb.	10.88
87	Equivalent evaporation per lb. dry fuel	lb.	11.32
88	Equivalent evaporation per sq. ft. heating surface per hr.	lb.	5.37
89	Units of evaporation absorbed per sq. ft. of boiler heating surface	U.E.	5.21
	(a) Percentage rating	percent	156

Efficiency

90	Efficiency of boiler, superheater, furnace, grate and air heater	percent	78
91	Comparative efficiency of boiler, superheater, furnace and grate (when not equipped with air heater)	percent	74.4
92	Efficiency including economizer	percent	.....
93	Comparative efficiency including economizer (when not equipped with air heater)	percent	.....

* Assumed.

Heat Balance of Steam-Generating Unit Comprising Boiler, Superheater, Economizer and Air Heater. Solid Fuels.

		B.t.u.	Percent
	Heat Values		
4094	Heat per lb. coal (dry) (higher heating value)	14088	100
4095	Heat absorbed by water and steam in boiler and superheater	10985	78
4096	Heat absorbed by steam in superheater	.....	...
4097	Heat absorbed by water in economizer	.....	...
	Losses		
4098	Heat loss due to combustible in refuse	108	.8
4099	Heat loss due to sensible heat in refuse	.....	...
4100	Heat loss due to incomplete combustion of carbon	100	.7
4101	Heat loss due to theoretical dry gases, T_2 to T_8	660	4.7
4102	Heat loss due to moisture in coal, and water from combustion of hydrogen, up to T_8	603	4.3
4103	Heat loss due to excess air entering furnace, T_2 to T_8	42	.3
4104	Heat loss due to air leaking through boiler setting, T_1 to T_8	64	.4
4105	Heat loss due to air and moisture leaking through economizer setting, T_1 to T_8	.....	...
4106	Heat loss due to air leaking through air heater setting, T_2 to T_8	226	1.5
4107	Heat loss due to unconsumed hydrogen and hydrocarbons, radiation, and unaccounted for	1310	9.3
	Economizer		
4108	Heat available to economizer in flue gases, including moisture, T_7 to T_{10}	.....	...
4109	Efficiency of economizer	.....	...
	Air Heater		
4110	Heat available to air heater in flue gases, T_7 to T_2	1293	...
4111	Heat absorbed by air heater	624	...
4112	Efficiency of air heater	.....	48

Note.—If unit does not include economizer do not fill out Items 4097, 4105, 4108 and 4109. If data are available for further segregation of losses, other items may be added.

to the propelling motor and the alternating current electric auxiliaries were measured by watt-hour meters.

The test run September 29 was from 9 a. m. until 5 p.m., readings being taken every hour. Tabulations of these readings are shown on Tables 1 and 2. From 9 a.m. until 10:40 a.m. no steam was extracted from the main unit for heating the feedwater as the water rate of the main unit was being checked, but at 11:40 a certain amount of steam was extracted for this purpose. Extracting steam for the feedwater heater should decrease the fuel consumption approximately 2.5 to 3 percent.

It was impossible to determine accurately the vacuum as the mercury column could not be read. The readings taken on vacuum gages show a poor vacuum, which was later found to be due to air leaks. An improvement in vacuum to 1.5-inch mercury absolute should result in a decreased fuel consumption of approximately 5 percent.

The boiler-feed readings used in the boiler test were

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TABLE 3.—TRIAL DATA, TESTS NOS. 2 AND 3

Time	Direct connected D.C. generator kw.	Meter reading: Gen. kw. hrs.	Meter reading: Motor input kw. hrs.	A. C. volts	Propeller R.P.M.
Constant		1000	1000		
7:30	36	4344.6	4039+	2350	
8:30	36	4348.7	4043	2390	
11.00	36	4357.75	4051.5	2350	
1:00	36	4365.25	4058.5	2450	
3:00		4373.5	4066	2350	
4:00	36	4377.3	4070	2450	
Average					
11—4	36	3860	3580	2400	
7:30—4 ..	36	3960	3650	2390	130

Average engine room temperature, 80° F.

TABLE 4.—TRIAL DATA, TESTS NOS. 2 AND 3

Time	Temp. cond. °C.	Temp. feed and filter °C.	Vacuum gages	Vacuum column	Steam pressure gage
7:30....	35½	79	28.0 28.2	27.85	310
8:30....	36	72	28	27.8	310
11:00....	36	68	28	....	310
1:00....	37	80½	28	....	310
3:00....	38	89	28	....	310
4:00....	37½	82	28	....	310

TABLE 5.—OPERATING DATA—AVERAGE OF 30 TRIPS

	Hours	Percent
Average full speed	57	76
Average check	2.05	2.75
Average delay	.77	1.05
Average loading	9.15	12.2
Average unloading	6.03	8.0
Total average	75.00	100.00
Average miles per hour	14.1	
Average coal per mile (including loading and unloading, pounds)	450	
Average cargo (gross tons)	14,450	
Average miles per trip	805	
Pounds of coal per ton-mile	0.031*	
Coal per s. h. p. hr., all purposes, including loading, unloading, time delayed, checked, etc.	1.39	
Average h. p. input to auxiliaries	354	
Average s. h. p. of propelling motor	4550	
Average coal per trip	361,600	
Average ton-miles per trip	11,642,000*	
Average h. p. input to d-c. auxiliaries	Not recorded	
Average ton-miles per pound of coal	32.2*	
Average cost of fuel per mile	.90	

* The Great Lakes operators, in order not to handicap their propelling engines, consider the ton-miles as the cargo carried multiplied by the total miles run light and loaded. In order to have these figures consistent with this practice, these values have been determined in this manner.

an average of three sets of readings, two of these sets of readings being steam readings and the third readings water.

The alternating-current generator kilowatt output and propelling-motor input were determined by means of integrating, kilowatt-hour meters. The difference between the generator output and motor input was the amount of power used by the alternating-current auxiliary motors. The amount of power furnished by the direct-connected exciter was determined by taking readings of the amperes and volts. These readings are shown on Table 1.

Knowing the main propelling motor efficiency from tests conducted in the factory, the power delivered to the propeller shaft was determined.

The total coal used during this run was 44,450 pounds, which is equivalent to 1.19 pounds of coal as fired per shaft horsepower hour for all purposes. At the end of this test it was discovered that combustion was not as good as it should have been, and therefore it was decided to take a second test with the ship running light from Buffington to Calcite. This second test was conducted October 1, 1927, from 7:30 a.m. until 4 p. m. During this test, maneuvering tests were taken to determine approximately the amount of torque utilized in stopping the ship. Due to these maneuvering tests, a second set of readings was started at 11 a.m. The average coal as fired per shaft horsepower hour, including the maneuvering tests, was 1.17 pounds per shaft horsepower hour, and the average from 11 to 4, or five hours, was 1.14 pounds of coal per shaft horsepower hour.

Reversal Tests

The first reversal test was made on the *Carl D. Bradley* about 10 a.m. October 1, readings being taken every ten seconds. The readings consisted of revolutions of the propelling motor and kilowatt input to the propelling motor, which has been converted into torque. From the time the captain gave the signal until the chief operated the levers there was a delay of about twelve seconds, as the chief wanted to know whether or not various observers were ready to take the readings. Ten seconds after the lever was moved, or about twenty-two seconds after the signal was given by the captain, the propeller was turning 50 revolutions astern with a torque of approximately 135 percent. This torque was gradually reduced until fifty-two seconds had elapsed when it was approximately 80 percent of full load torque of the motor. The torque varied slightly, until about 232 seconds after the signal it increased to 90 percent; at 242 seconds after the signal the torque went up to 130 percent and then dropped to 115 percent. The ship was dead in the water three minutes and fifty-five seconds or 235 seconds after the signal. In other words, it looks as if the torque of the motor increased just as the ship came to rest in the water. The estimated speed of the ship just before the reversal test was taken was 14.7 miles.

During the 1927 operating season the chief engineer of the *Carl D. Bradley* stated that in stopping the ship going through the Detroit River he had used approximately the same amount of power as was observed during these reversal tests.

There has been some discussion as to whether or not a propeller could utilize full horsepower in backing, and it appears from the tests conducted that this power can be used. We did not endeavor, in making these reversal tests, to stop the ship in the shortest possible time: the chief made a normal reversal. The wheel was reversed in about twenty seconds, which we do not believe abnormal with reciprocating engines.

Summary

The turbine electric drive on the *T. W. Robinson* and *Carl D. Bradley* have proven adaptable.

The low cost of maintenance of turbine electric drive on a Great Lakes cargo ship can only be proven by time, but based on ships operated at sea it is less than a reciprocating steam engine.

The automatic stokers allow the use of slacked coal, with a 20 per cent saving in the cost of fuel, and on the *Carl D. Bradley* have eliminated six firemen.

The tests conducted on the water-tube boilers, using stokers, indicate that this type of boiler is as efficient if not more efficient than the hand-fired Scotch boiler.

The *Carl D. Bradley* requires between 1.15 and 1.2 pounds of coal per shaft horsepower hour for all purposes when running under a constant steaming condition against 1.65 to 2.25 pounds per shaft horsepower hour for the reciprocating steam engine as operated on the Great Lakes. The overall coal consumption for thirty trips in 1927 on the *Carl D. Bradley,* which is a self-unloader, including all coal used when loading, unloading, delayed, etc., was 1.39 pounds per shaft horsepower. This is equivalent on a cost basis, using slacked coal, to .47 pound of Diesel oil per shaft horsepower for all purposes, including all fuel used loading, unloading, delayed, under way, etc.

The average gross ton-miles per pound of coal as fired for thirty trips in 1927 was 32.2.

The average gross ton-miles per pound of coal as fired up to September, 1928, is 32.58.

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Questions and Answers for Engineers

Practical information on the operation and maintenance of boilers, engines and auxiliaries

This department is maintained to help those who desire practical information regarding engine room problems or who are preparing to take examinations for a marine engineer's license. Readers are urged to send in questions. Inquiries bearing the name and address of the writer will be answered promptly by mail. If the question is of general interest the answer will also be published in an early issue of the magazine, although the identity of the writer will not be disclosed in doing so. Anonymous communications will not be considered.

Shoulders in a Cylinder

Q.—What is the cause of shoulders forming in a cylinder?

A.—Unless the piston ring overruns the cylinder counterbores, shoulders will form where the stroke ends.

Low Water in a Boiler

Q.—What are some of the effects of low water in a boiler?

A.—With a hot fire under a boiler and with insufficient water in the boiler to absorb the heat given off by the furnace, the following is very liable to happen: Warping of boiler casing, distortion of boiler-heating surface, destruction of boiler brickwork, serious steam and water leaks, and danger of boiler explosion.

One-Sided Wear in Cylinder

Q.—What causes a one-sided wear or flat in a cylinder?

A.—A one-sided wear or flat is caused by the piston being out of line, resulting from either the piston rod being bent or out of line; several adjoining broken piston ring springs; poorly distributed clearance between sides of piston rings and flanges of piston and follower; too much clearance between follower and cylinder walls; broken piston ring.

Condenser Cleaning

Q.—How would you proceed to boil out and clean the steam side of a surface condenser?

A.—Grease and dirt on the steam side of a condenser are removed by boiling out with a strong solution of sal soda and kerosene. Drain the salt-water side and close the air-pump suction and all other valves. For each 1000 gallons of water the condenser will hold, make a mixture of 200 gallons of fresh water with 50 pounds of sal soda and five gallons of kerosene; after this solution is thoroughly mixed, empty it into the condenser. Fill the steam side of the condenser with fresh water to above the top row of tubes, unless water at this height when brought to the boiling temperature will overflow into the exhaust trunk. In such cases the height will have to be regulated so that no overflow will take place. Turn live steam into the condenser and bring the contents to the boiling point at atmospheric pressure. Boil for about 12 hours. Be sure boiling takes place as sometimes an engineer is misled by the vibration and noise resulting from admitting live steam to the condenser. After 12 hours of steady boiling, drain the condenser into the bilge. Be very careful that none of the solution is admitted to the feed system. Remove the inspection plate at the bottom and wash out several times with fresh water, making sure that all sediment is taken from the bottom of the shell. Close the condenser, fill with fresh water and test same for leaks.

Inaccuracy of Meters

Q.—What are some of the causes of inaccuracy of meters?

A.—Meters become unreliable from friction, leakage, erosion, worn parts, freezing, etc. The moving parts in the measuring chamber may become incrusted with deposits from the liquid measured. The packing around the driving spindle of the indicator gear train may exert too much friction. Gears may not mesh properly due to wear or having been improperly fitted. Worn bearings in the gear trains. Foreign matter obstructing the submerged gear train. Hard-rubber disks or bushings warped by exposure to temperatures higher than 100 degrees F.

Lifting Gear

Q.—What are some of the most important things for an engineer to look after in regards to lifting gear and safe loads for same?

A.—An engineer should carefully inspect the lifting devices, such as slings, chain falls, chains, chain blocks, cables, spreaders, beams, eyebolts, etc., to detect any weakness. No device of a doubtful character should ever be used. He should familiarize himself with the following data: Safe loads for steel beams, safe loads for manila ropes and slings, safe loads for wire cable and wire slings, safe loads for eyebolts when loaded in various directions, varieties of useful hitches and knots, weights of the various parts to be lifted. Lifting devices should never be loaded beyond their rated capacities.

Firing an Oil-Fired Boiler

Q.—What are the general requirements for efficient firing of an oil-fired boiler?

A.—Every member of the fireroom force should become thoroughly acquainted with every detail of the fireroom installation. Supplying the proper quantity of oil to obtain the desired rate of combustion. Supplying the proper quantity of air to support combustion of the oil burned. Reducing excess air to a minimum. Finely atomizing the oil just prior to its coming in contact with the air for combustion and thoroughly mixing the air for combustion with this oil. Maintaining a high furnace temperature, necessary to assist in obtaining complete combustion.

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Scored Cylinders

Q.—What are some of the causes for cylinders becoming scored?

A.—Hard particles of dirt, rust or grit left in the ports or in the cylinder itself or carried over with the steam, especially when the boilers prime. The edges or ends of the rings nipping and cutting the cylinder walls or the edges of countersunk bolts not being perfectly flush. Packing ring being forced too hard against the cylinder walls by springs which are too strong or by steam pressure exerted behind the ring. Broken piston ring.

The erosive effect of steam aggravates scores started by any one of the above-mentioned causes.

Flash Point of Oil

Q.—What is meant by the flash point of an oil?

A.—The flash point of an oil is the temperature at which inflammable vapors are given off sufficient to "flash" when brought into contact with a flame. The heavier the oil, the higher the flash point, although there may be considerable variation between two oils of the same viscosity refined from crudes of different characteristics. The following table shows the flash points of a series of oils produced from the same stock:

Ice machine, 298 degrees F.; light, 320 degrees F.; medium, 324 degrees F.; heavy, 330 degrees F.; extra heavy, 350 degrees F., and mineral cylinder, 490 degrees F.

Chemical Symbols

Q.—What governs the arrangement of letters and subs denoting the symbols for chemical compounds and mixtures? Why should sulphuric acid always have the letters of its symbol H_2SO_4 instead of O_4SH_2 or SH_2O_4?

A.—A group of atoms that exist in the molecule of a compound and is transferred unbroken in chemical changes to the molecules of other compounds is called a radical.

Acids are hydrogen compounds. The hydrogen in them is combined either with a single atom of a non-metal, as in the case of H Cl or with a radical composed of non-metallic atoms as in HNO_3, H_2SO_4 and H_3PO_4.

Accordingly, the element which is common to all acids, hydrogen, is placed first in writing the formula. The element or radical which determines the kind of acid follows. The elements forming the radical are not separated because of their special relationship already defined.

Horsepower Required

Q.—There is contemplated a boat 270 feet long, 42 feet beam, 9 feet draft. Speed is to be 12 miles per hour. Full load displacement is to be 2200 long tons. Twin screws and electric drive. Other particulars are as follows: Block coefficient, 0.754; midship coefficient, 0.98; prismatic coefficient, 0.768; speed-length ratio, 0.639; displacement-length coefficient, 106. I want to know the horsepower (shaft) required in each motor (one motor to each propeller) to give the required speed and most suitable diameter and pitch of the propeller.

A.—It is assumed that the 270 feet to which you refer is the length of the vessel on the waterline.

It is assumed further that the speed which you quote is 12 statute miles or 10.44 knots, as this checks closely with the speed-length ratio which you give. The beam to draft ratio is rather extreme and introduces an element of uncertainty into the estimate for power, inasmuch as this ratio lies beyond the range usually met in practice.

The draft quoted is rather small and the question arises as to the depth of channel in which it is proposed to operate the vessel. The figures given below assume deep water, that is, a channel depth of 50 or 60 feet for the subject vessel. In case operation in shallow water is contemplated, the power figures will be considerably more than those quoted below.

With the foregoing in mind, an effective horsepower of 430 to 450 may be anticipated at a speed of 10.44 knots. This is a bare-hull horsepower. With the twin-screw installation which you contemplate and assuming that the hull appendages will consist of rudder, outboard shafting and struts, and bilge keels, an addition of 12 to 15 percent should be made to the bare-hull effective horsepower. This will give a total effective horsepower of from 495 to about 520.

To this point the work done may be considered reasonably satisfactory for preliminary purposes, because the data furnished are adequate. However, in order to make a reasonable approximation to propeller characteristics, a plan showing the lines of the after-body and information as to the range of revolutions per minute desirable for the motors should be furnished.

In connection with the foregoing, you will appreciate that exhaustive investigations of resistance and propulsion problems do not come within the scope of this department.

Lubricating System

Q. What are the most important precautions to be taken in regards to the lubricating system while under way?

A.—(1) If oil supply is interrupted for any reason, stop machinery concerned immediately; make necessary repairs or adjustments and restore oil supply before resuming operation. (2) If a sudden increase of pressure at the oil pumps is noted, the flow of oil at the bearings shall be inspected immediately. This trouble is usually due to a clogged strainer. (3) Two oil pumps should be habitually used, cross-connected, even though one will maintain the required pressure, as the failure of one pump under these conditions will not result in a complete failure of the lubricating system. (Note.) In freight ships one pump is enough, provided a second pump is kept warmed up with all valves open, except either the suction or discharge valve. (4) At the first indication of a rise in temperature of the lubricating oil supply, increase the speed of the oil-service pumps and oil-cooling pump. (5) Every precaution should be taken to prevent the entry of water into the lubrication system. (6) Examine the sight feed of the lubricating system frequently during the watch and see that all drains are open and clear. (7) Spray nozzles of a reduction-gear lubricating system should be kept open at all times. The level of oil in gear casings must not rise to such a height that the gear tips become immersed. Such immersion causes churning, emulsification and a sudden increase in temperature. (8) Oil coolers should be used, if the temperature of the oil rises above 100 degrees F. Bearing temperatures in turbine installations may safely run as high as 130 degrees to 140 F. with an upper limit of 160 degrees F. With reciprocating engines, the temperatures should not exceed 110 degrees F. Unless specifically constructed to do so, ball bearings should not run at temperatures in excess of 200 degrees F. When operating at maximum temperatures, extreme vigilance must be observed, and if temperatures cannot be controlled by increasing the speed of the oil pumps and oil-cooler pumps, the engines should be slowed down or stopped as found necessary. (9) When oil coolers are not in use, keep the salt water side drained.

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Questions and Answers Relating to Ship Design and Construction

By J. L. Bates, Naval Architect, and W. B. Newton, Marine Engineer

This department is maintained for the purpose of answering all questions relating to ships and their machinery. All inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given permission to do so.

A Problem in Trigonometry

Q.—Is a mathematical solution of the following problem possible? If so, what are the necessary steps? Given an angle of 36 degrees of an unknown radius, divided into two unequal angles, as shown; the problem is to find radius R and the two angles B and B_1. Can you supply a method of solution that can be applied to similar problems with other than an angle of 36 degrees and different values of sides b and b_1?

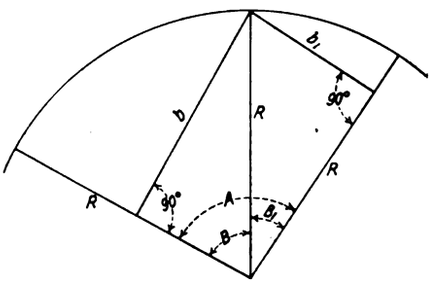

Fig. 1

A.—In the following, general expressions for the conditions stated are derived. These expressions are then used to ascertain the numerical values desired.

$$\frac{b}{R} = \sin B \text{ and } \frac{b_1}{R} = \sin B_1$$

$$\sin B + \sin B_1 = \frac{b}{R} + \frac{b_1}{R} = \frac{b + b_1}{R}$$

$$\text{But } \sin B + \sin B_1 = 2 \sin \frac{1}{2}(B + B_1) \cos \frac{1}{2}(B - B_1)$$

$$= 2 \sin \frac{1}{2} A \cdot \cos \frac{1}{2}(B - B_1)$$

$$\text{Therefore, } 2 \sin \frac{1}{2} A \cdot \cos \frac{1}{2}(B - B_1) = \frac{b + b_1}{R} \quad (1)$$

$$\text{and, } \sin B - \sin B_1 = \frac{b}{R} - \frac{b_1}{R} = \frac{b - b_1}{R}$$

$$\text{now } \sin B - \sin B_1 = 2 \cos \frac{1}{2}(B + B_1) \cdot \sin \frac{1}{2}(B - B_1)$$

$$= 2 \cos \frac{1}{2} A \cdot \sin \frac{1}{2}(B - B_1)$$

$$\text{Therefore, } 2 \cos \frac{1}{2} A \sin \frac{1}{2}(B - B_1) = \frac{b - b_1}{R} \quad (2)$$

Dividing (1) by (2)

$$\sin \frac{1}{2} A \cdot \cos \frac{1}{2}(B - B_1) = \frac{b + b_1}{R}$$

$$\cos \frac{1}{2} A \cdot \sin \frac{1}{2}(B - B_1) = \frac{b - b_1}{R}$$

$$\text{Then } \tan \frac{1}{2} A \cdot \cot \frac{1}{2}(B - B_1) = \frac{b + b_1}{b - b_1}$$

If A, b and b_1 are known, then $\cot \frac{1}{2}(B - B_1)$ becomes known for it is equal to $\left\{ \frac{b + b_1}{b - b_1} \right\} \cot \frac{1}{2} A$. This determines $B - B_1$. However, $B + B_1$ is known. Therefore B and B_1 are found and R can be found from the expression

$$R = \frac{b}{\sin B} = \frac{b_1}{\sin B_1}$$

Now, if $B + B_1 = 36° = A$, then $\frac{1}{2} A = 18°$

and $\cot 18° = 3.07768$.

and if $b = 3\frac{1}{8}$ and $b_1 = 1\frac{7}{8}$,

then $\frac{b + b_1}{b - b_1} = \frac{5}{1.25} = 4.$

$$\cot \frac{1}{2}(B - B_1) = 4 \times 3.07768 = 12.31072$$

$$\frac{1}{2}(B - B_1) = 4° \quad 38.68'$$

$$B - B_1 = 9° \quad 17.36'$$

and $B + B_1 = 36° \quad 0'$

whence

$$2B = 45° \quad 17.36'$$

$$B = 22° \quad 38.68'$$

$$B_1 = 13° \quad 21.32'$$

$$R = \frac{b}{\sin B} = \frac{3.125}{0.38501} = 8.11667$$

$$R = \frac{b_1}{\sin B_1} = \frac{1.875}{0.23100} = 8.11688$$

This problem can also be solved by the use of graphics. That given above is probably more satisfactory.

Turbines

Q.—What is a complete expansion turbine, a single unit, and a cross-compound?

A.—It is not clear as to what you mean by a complete expansion turbine unless it is one in which the pressure is compounded with alternate rows of fixed and moving blades as in reaction turbines. The steam expands in both the fixed blades, which are attached to the casing, and the moving blades, which are fixed in the rotor. Here we have practically a continuous expansion of steam from the inlet to the exhaust of the turbine.

A single unit is one in which all the steam expansion from the throttle to the condenser takes place within one casing.

In cases where a turbine would be too large to be contained in a single casing it is advantageous to divide it into two parts and designate them as high-pressure and low-pressure units. To put these two elements

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on one shaft would limit the rotational speed of the high-pressure to that of the low-pressure turbine, an arrangement which would not operate to the best advantage; therefore they may be separated and each made to drive its own shaft.

Personal

Frank Sayles, formerly chief turbine inspector of the **United States Shipping Board,** has been appointed assistant port engineer of the **American Republics Line.**

L. S. Andrews, formerly assistant port engineer of the **American Republics Line,** has been appointed superintending engineer of the **Export Steamship Corporation,** New York.

B. A. Harnett has been appointed assistant to the vice-president in charge of operations of the **Merchant Fleet Corporation** to fill the vacancy caused by the recent resignation of **H. F. Markwalter.** Mr. Harnett, a native of California, received his education at the University of California. Upon leaving college he accepted a position with the **Pacific Mail Steamship Company** and remained with this organization for seven years. Mr. Harnett next served for three years with the **Oregon Railroad and Navigation Company,** which later was reorganized as the **San Francisco and Portland Line.** Mr. Harnett then joined the **Oriental Steamship Company** in which service he became assistant to the general manager. After the World War, he accepted a position as supercargo with the **Merchant Fleet Corporation** making several trips to South America and Europe. At the close of this duty he became assistant to the manager of the operating department. He was next commissioned to establish the South Atlantic District of the **Merchant Fleet Corporation** and became its first director. He resigned shortly thereafter and assumed the position of operating manager of the **Black Diamond Steamship Company.** Mr. Harnett stayed with this organization for a little over two years. When he was again called back to the **Merchant Fleet Corporation** as special assistant to the operating manager, he organized the revenue and expense division and became the manager of this branch.

B. A. Harnett

William M. Kennedy, for the past six years general superintendent of the **W. & A. Fletcher Company,** Hoboken, N. J., has resigned his position to become associated with the **Condenser Service & Engineering Company, Inc.,** Hoboken, N. J. **Austin Donar,** general foreman machinist for the **W. & A. Fletcher Company,** also has joined the **Condenser Service Company.**

John C. Sterling, formerly assistant superintendent in charge of north side shops of the **Newport News Shipbuilding and Dry Dock Company,** Newport News, Va., has been promoted to the position of chief of the machine shop division of that company. Mr. Sterling will fill a vacancy caused by the resignation of **Chester B. Lord,** former superintendent of machine shops, who has recently become associate editor of the *American Machinist.*

H. F. Markwalter, formerly principal assistant to the vice-president in charge of operations of the **Merchant Fleet Corporation,** Washington, D. C., has resigned to take the position of assistant general manager of the **Colombian Steamship Company,** New York City. Mr. Markwalter was born in Brooklyn, N. Y., and was educated in the public schools and the Commercial High School of Brooklyn. He embarked upon his career in the marine field in 1906 as stenographer to **H. H. Raymond,** president of the **Clyde Steamship Company.** In 1908 at the time of the consolidation of the Clyde and Mallory Lines Mr. Markwalter became the statistician of that concern; in 1910 he became chief clerk and in 1917 he became operating assistant to the general manager. In 1918, in addition to his duties with the Clyde and Mallory Lines, Mr. Markwalter became assistant treasurer of the **Gulf & Southern Steamship Company,** resigning from this position in 1926. Mr. Markwalter became assistant secretary and assistant treasurer of the **Colombian Steamship Company, Inc.,** in 1923; assistant treasurer of the Clyde and Mallory Lines in 1924, and assistant secretary and assistant treasurer of the **Ocean Transport Company, Inc.,** in 1926. In 1927, Mr. Markwalter resigned from his interests in these companies to accept his previous position with the **Merchant Fleet Corporation.**

Obituary

Charles E. Mather, of **Mather & Company,** marine insurance brokers of Philadelphia and New York, died on October 31 at his home in Haverford, Pa. Mr. Mather was widely known as an expert on marine insurance and had been a member of the **American Bureau of Shipping** and of the American committee of **Lloyd's Register of Shipping** for many years. Mr. Mather was 78 years of age.

Henry Steers, for many years president of the engineering firm of **Henry Steers, Inc.,** New York city, died recently at his home in Port Chester, N. Y. Mr. Steers was born in New York city and was educated at St. Paul's School, Concord, N. H. In 1904, he founded the engineering firm of Henry Steers, Inc., which has aided in the construction of some of the most important railroads along the eastern seaboard. His activity in this line led to his selection as one of the engineers for the erection of New York city piers. His work in the marine field has made him widely known in terminal and pier construction. Mr. Steers was a yachting enthusiast, being a member of the New York Yacht Club. Other organizations of which he was a member are the Union Club, Brook Club, Racquet and Tennis Club, India House Club, Whitehall Club and the Merchants Fowling Club.

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Ship Construction and Repair News

Proposed work—Bids asked—Bids received—Contracts awarded—Current activities

American South African Line Awards Contract for 10,000-Ton Motorship

A CONTRACT for the construction of a 10,000-ton motorship for the South African trade has been awarded by the American South African Line, Inc., 39 Cortlandt street, New York, N. Y., to the Sun Shipbuilding & Drydock Company, Chester, Pa. This vessel, which will conform to all the provisions of the Merchant Marine Act of 1928, is the second vessel to be built under the terms of the Jones-White bill.

The vessel will have a length of 470 feet 8 inches, a molded breadth of 61 feet 6 inches, and a draft of 26 feet. The hull, designed on the transverse frame system, is of the three-deck type, with extended forecastle, long bridge, cruiser stern, and with a capacity below decks in excess of 464,000 cubic feet bale measurement for cargo. This vessel will be of twin-screw Diesel drive, the propelling machinery consisting of two sets of Sun-Doxford, opposed-piston, double-acting, solid-injection, internal expansion oil engines. These engines will develop in excess of 5000 shaft horsepower, capable of producing a sustained sea speed in ordinary weather of 13 knots on an economical fuel consumption.

All auxiliaries are to be electric, power for which is to be generated in three Diesel direct-driven motor-generator sets. The vessel is to be equipped with all modern appliances. Double rigged hatches will permit the vessel to handle the wide variety of merchandise exported to and imported from South Africa. Accommodations are provided for 60 first-class passengers. All passenger rooms are located outside on the upper deck and so ventilated as to give maximum comfort in tropical climates. Public rooms consist of a well appointed lounge, smoking room and dining room.

The plans were under the supervision of John J. Farrell, Arthur R. Lewis, and Leigh C. Palmer, directors of the American South African Line, Inc.

The vessel is expected to be completed in December, 1929.

Bids Received for Construction of Two Night Line Boats

PROPOSALS for the construction of two Diesel-propelled vessels for the Hudson River Night Line, New York city, were opened privately in the offices of Henry J. Gielow, Inc., New York city, designers of the vessels, a short time ago.

The proposed ships will have a length of 325 feet, a beam of 58 feet, and a depth of 23 feet. They will each be of twin-screw propulsion, each screw being driven by a Diesel engine of approximately 1600 horsepower. No decision on the award of a construction contract has as yet been announced.

The Month's New Construction Contracts

One passenger liner for the Grace Line, Inc., New York city, awarded to the New York Shipbuilding Company, Camden, N. J.

One 10,000-ton freight and passenger motorship for the American South African Line, Inc., New York city, awarded to the Sun Shipbuilding & Drydock Company, Chester, Pa.

Three pleasure yachts for Alfred E. Sloan, Jr., president of General Motors; Fred J. Fisher, official of the same organization, and another automobile executive, whose name was not released, awarded to the Pusey & Jones Corporation, Wilmington, Del.

One 250-foot Diesel-propelled tanker for the Tide Water Oil Company, 11 Broadway, New York city, awarded to the Pusey & Jones Corporation, Wilmington, Del.

One 255-foot oil tanker for the Sun Oil Company, Philadelphia, Pa., awarded to the Sun Shipbuilding & Drydock Company, Chester, Pa.

One yacht for Charles F. Ketterling, chief engineer of General Motors, awarded to the Defoe Boat & Motor Works, Bay City, Mich.

One yacht for Jules S. Bache, New York financier, awarded to Robert Jacob, Inc., City Island, N. Y.

Two 115-foot Diesel-electric ferryboats for the Manhattan State Hospital, Ward's Island, N. Y., awarded to the New London Ship & Engine Company, Groton, Conn.

One 250-foot towboat and one pineapple barge for the Inter-Island Navigation Company, Ltd., Honolulu, T. H., awarded to the San Francisco plant of the Bethlehem Shipbuilding Corporation, Ltd.

One 121-foot steel-hull harbor-patrol boat for the United States Supervisor of New York Harbor, 39 Whitehall Street, New York, N. Y., awarded to the Snedden Shipbuilding Company, Inc., Baltimore, Md.

One Diesel tugboat for the Conners Marine Company, Inc., 17 Battery Place, New York city, awarded to A. C. Brown & Sons, Tottenville, N. Y.

Five coal barges for the Monessen Coal & Coke Company, Frick Building, Pittsburgh, Pa., awarded to the Riter-Conley Company, Pittsburgh, Pa.

Four barges for the Pittsburgh Plate Glass Company, Pittsburgh, Pa., awarded to the Midland Barge Company, Midland, Pa.

Three steel barges for the United States Engineer Office, Wilmington, N. C., awarded to the Atlantic Ellis Channel System, Inc., New York city.

Three flush-deck type barges for the Ohio River Sand Company, Louisville, Ky., awarded to the Dravo Contracting Company, Pittsburgh, Pa.

One nine-ton convertible steel-hull dredge for the Department of Wharves, Docks & Ferries, Philadelphia, Pa., awarded to the Kensington Shipyard & Drydock Company, Philadelphia, Pa.

Ward Line Asks Bids for Construction of Two Liners

PLANS and specifications for the construction of two fast passenger and cargo liners for the New York & Cuba Mail Steamship Company (Ward Line) have been issued to shipyards for bids. Tenders will be received at the offices of the Ward Line, Foot of Wall street, New York, N. Y., on December 20.

The new vessels will have a length overall of 508 feet; a length between perpendiculars of 482 feet; a beam of 69 feet 8 inches; a depth of 39 feet, and a draft of 26 feet. They will be propelled at a speed of 19 knots by twin screws, driven by geared turbines having a total horsepower of 14,600. Steam will be developed by six watertube boilers. All the auxiliaries and deck machinery will be driven by electricity.

Accommodations for 475 passengers of both first and tourist class will be included.

Grace Line Awards Contract for New Liner Construction

THE Grace Line, Inc., 10 Hanover square, New York city, recently awarded a contract for the construction of a new passenger liner to the New York Shipbuilding Company, Camden, N. J. The new vessel will be 502 feet long overall, about 64 feet beam, turbo-electric drive generating 12,000 shaft horsepower, speed 18 knots, and will carry first-class passengers only to the number of 175. Her freight capacity will exceed 7000 tons, and the vessel will have exceptionally large hatches and gear to accommodate a lifting capacity of 75 tons. All winches and auxiliary machinery will be electrically operated. Bids for the work were opened privately on August 4.

Dollar Line Awards Contract for Conditioning Four Ships to Newport News Yard

THE Dollar Steamship Line, San Francisco, Cal., following negotiations at San Francisco with representatives of the Newport News Shipbuilding & Drydock Company, Newport News, Va., has awarded the work of reconditioning the steamship *Manchuria* to that company. It is reported that the contract price was approximately $340,000 and that the work is to be completed on or before January 23, 1929.

It is also understood that a contract has been closed between the Dollar Steamship Line and the Newport News Shipbuilding & Drydock Company for rebuilding two and possibly three of the 502-foot class of vessels operated in the round-the-world service. The work includes extensive structural work of building in the space between the bridge and the main superstructure, providing additional passenger accommodations and facilities to meet the increased demand of the trade. It is reported that more than $250,000 is involved for each vessel and that approximately three months is required to do the work on each vessel. The first vessel is to follow the *Manchuria*, and the present schedule of service of the Dollar round-the-worlders will be maintained without interruption as the work will be done in sequence.

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Contracts for Constructing Five Yachts Awarded

THREE pleasure yachts, each costing approximately $1,000,000, have been designed for Alfred E. Sloan, Jr., president of General Motors; Fred J. Fisher, official of the same organization, and another automobile executive, whose name was not released, by John H. Wells, 11 E. 44th St., well-known New York naval architect in association with Cox & Stevens, naval architects, 347 Madison avenue, New York city.

Two additional orders calling for the construction of a $500,000 yacht for Charles F. Ketterling, chief engineer of General Motors, and a $200,000 yacht for Jules S. Bache, New York financier, were placed at the same time. The five yachts will cost approximately $3,700,000.

The $1,000,000 yachts will be built by the Pusey & Jones Corporation, Wilmington, Del. They will have an overall length of 236 feet, beam of 34 feet and draft of 14 feet. Each vacht will be driven by two six-cylinder airless Winton Diesel engines of 1100 horsepower, at a speed in excess of 15 knots.

The yacht designed for Mr. Ketterling will be built at the Defoe Boat & Motor Works, Bay City, Mich. She will be 170 feet long, 26 feet beam, and will be driven by two Winton Diesel engines, at a speed of 14 knots.

Mr. Bache's vessel will be constructed at the shipyard of Robert Jacob, Inc., City Island, N. Y. This vessel will be 112 feet long, 19 feet beam, and will be driven by Winton Diesel engines, at a speed of 18 knots.

Contract for Two New York State Ferries Awarded

A CONTRACT for the construction of two 115-foot Diesel-electric ferryboats for the Manhattan State Hospital, Ward's Island, N. Y., was awarded recently to the New London Ship & Engine Company, Groton, Conn., at a price of $207,000. Bids for the work were received by Lewis M. Farrington, secretary of the Department of Mental Hygiene, Albany, N. Y., on September 28.

Contracts for furnishing the machinery and electrical equipment for these vessels also were awarded recently. The Winton Engine Company, Cleveland, Ohio, received the contract for the machinery at a price of $110,000, while the General Electric Company, Schenectady, N. Y., will supply the electrical equipment. Bids for the machinery were received at Albany on October 10.

Tide Water Oil Co. Awards Tanker Construction Contract

A CONTRACT for the construction of a 250-foot Diesel-electric tanker for the Tide Water Oil Company, 11 Broadway, New York, N. Y., was awarded recently to the Pusey & Jones Corporation, Wilmington, Del. Bids for the work were received in New York on October 25. This vessel will have a breadth of 44 feet, a draft of over 18 feet 6 inches, a deadweight of over 2350 tons and will be equipped with De La Vergne engines.

Contract for N. Y. Harbor Patrol Boat Construction Placed

THE United States Supervisor of New York Harbor, 39 Whitehall street, New York city, has awarded a contract for the construction of one 121-foot steel-hull patrol vessel to the Spedden Shipbuilding Company, Inc., Baltimore, Md., at a price of $176,945 and a time of 425 days. Bids for the work were received in New York on October 24.

The new boat is to have a length, overall, 121 feet 5½ inches; length between perpendiculars, 114 feet; length of main deck, molded, 120 feet 3 inches; breadth, molded, 24 feet; breadth, overall, 25 feet 4⅞ inches; depth at side, molded, 13 feet 3 inches; depth at center line, molded, 13 feet 9 inches; sheer forward, molded, 4 feet 9 inches; sheer aft, molded, 3 feet, and camber in 24 feet, molded, 6 inches.

Sun Oil Co. Awards Contract for Tanker Construction

CONTRACT for the construction of one oil tanker for the Sun Oil Company, Philadelphia, Pa., was awarded recently to the Sun Shipbuilding & Drydock Company, Chester, Pa. The new vessel will have a length of 255 feet overall, and a beam of 43 feet. She will be similar in construction to the Sun Oil Company tanker *Sunoco*.

Bids Asked for Construction of Four Tankers

PLANS and specifications for the construction of four single-screw motor tankers for coastwise and canal trade have been issued from the offices of Angelo Conti, 11 Broadway, New York, to shipyards for bids. The vessels are to have a length overall of 243 feet, 6 inches; a length between perpendiculars of 235 feet; a beam of 38 feet, 6 inches; a depth of 15 feet, and a displacement of 1600 tons.

Contract Awarded for Construction of Steel Hull Dredge

A CONTRACT for the construction of a nine-ton convertible steel-hull dredge for the Department of Wharves, Docks & Ferries, Philadelphia, Pa., has been awarded to the Kensington Shipyard & Drydock Company, Philadelphia, Pa. Bids for the work were received in Philadelphia on October 17, 1928, and the Kensington shipyard was low bidder with a price of $23,875. Two other bids were received—one from the Ellicott Machine Corporation, Baltimore, Md., who submitted a price of $29,400, and one from the John J. Mathis Company, Camden, N. J., for $30,000.

U. S. Engineers Ask Bids for Constructing Two Barges

SEALED proposals will be opened by the United States Engineer Office, 1006 McCall building, Memphis, Tenn., at 11:00 a.m., November 30, 1928, for constructing and delivering two mooring and fascine barges.

U. S. Engineers Award Contract for Constructing Three Barges

THE United States Engineer Office, War Department, Wilmington, N. C., has awarded a contract for the construction of three steel barges to the Atlantic Ellis Channel System, Inc., New York city, at a price of $9750 each. Tenders for the work were received on October 22.

Two types of barges were given consideration: Plate steel barges constructed with shell and deck formed of steel plates, and channel steel barges constructed with shell and deck formed of structural steel channels. Bidders were requested to submit proposals for either or both types of barge. The three barges will be of channel steel construction.

Contract for Towboat and Barge Construction Awarded

THE Inter-Island Navigation Company, Ltd., 75 Queen street, Honolulu, T. H., recently awarded contracts to the San Francisco plant of the Bethlehem Shipbuilding Corporation, Ltd., for the construction of a tug and a pineapple barge.

The new tug is to be 250 feet long and is to be twin screw, equipped with two Diesel engines of 1150 horsepower, and the latest apparatus, including towing gear. The contract calls for the completion of the tug within a period of seven months.

The barge, which is to be a steel carrier, is to be completed at the earliest possible time.

Puget Sound Navigation Co. to Build Two Ferryboats

IRA Bronson, president of the Puget Sound Navigation Company, Seattle, Wash, has announced that in addition to a ferryboat for the Seattle-Victoria route, his company will build a ferryboat for the Seattle-Bremerton route, which will replace the *Seattle* and *Chippewa*.

The new ferryboat for the Bremerton route will make the trip in 40 minutes. Models for the two contemplated vessels have been made by the Lake Washington Shipyards, Houghton, Wash. It is hoped to have the keels for both vessels laid by December 1 so the new ferries will be ready for service next spring.

Kitsap County Transportation Co. to Ask Bids on Two Ferryboats

THE Kitsap County Transportation Company, Pier 3, Seattle, Wash., will shortly issue plans and specifications for the construction of two ferryboats. One will be a 200-foot vessel with a capacity of 90 automobiles for the Medina route on Lake Washington to replace the ferry *Leschi*, costing approximately $200,000. The other will be a 200-foot vessel with a capacity of 90 automobiles for the Puget Sound routes, at a price of $200,000.

The new vessels will be of the latest type and design and will be propelled by Diesel engines.

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Bids Asked for Construction of Puget Sound Ferry

PLANS and specifications for the construction of a steel passenger and automobile ferry steamship were issued recenty by Ira Bronson, president of the Puget Sound Navigation Company, Seattle, Wash. The new vessel is to have a length of 250 feet; draft of 16 feet; speed of 16 to 18 miles, and a displacement of 2000 tons. She is to be equipped with turbo-electric drive, developing 3500 horsepower.

The steamship is to be operated in the night passenger freight and ferry service between Seattle, Wash., and Victoria, B. C. She is to be completed by June 29, 1929.

Plans for Rebuilding S.S. Mount Clay to be Issued Soon

PLANS for rebuilding the steamship *Mount Clay* are nearing completion in the office of Theodore E. Ferris, naval architect, 30 Church street, New York city. When finished, these plans will be sent to the offices of the Dollar Line in San Francisco, Cal., for approval, after which they will be submitted to the shipyards for bids. It is expected that the cost of rebuilding this vessel will be between $750,000 and $1,000,000.

Midland Barge Co. to Build Four Barges

THE Pittsburgh Plate Glass Company, Pittsburgh, Pa., has awarded a contract for the construction of four barges to the Midland Barge Company, Midland, Pa. The price involved was not given out.

Riter-Conley Co. to Build Five Coal Barges

THE Monessen Coal & Coke Company, Frick building, Pittsburgh, Pa., recently awarded a contract for the construction of five coal barges to the Riter-Conley Company, Pittsburgh, Pa. The price involved could not be learned.

Contracts for Construction of Two Car Ferries Pending

CONTRACTS for the construction of two car ferries will be placed shortly by the Pere Marquette Railroad, Detroit, Mich. The Manitowoc Shipbuilding Corporation, Manitowoc, Wis., is reported low bidder for the work.

Dravo Co. Awarded Contract for Three Barges

A CONTRACT for the construction of three flush-deck type barges was recently awarded to the Dravo Contracting Company, Pittsburgh, Pa., by the Ohio River Sand Company, Louisville, Ky. The price involved was not made public.

Construction and Repair Bids

The Spear Engineers, Inc., Bids Low for Constructing Four Export Liners

TENDERS for the construction of four passenger and cargo vessels for the Export Steamship Corporation, 25 Broadway, New York, N. Y., were received in the office of the Corporation on Monday, November 5. The vessels are to have a length between perpendiculars of 450 feet; breadth of 61 feet 6 inches; depth, molded to second deck, 33 feet 3 inches; depth molded to shelter deck, 42 feet 3 inches, and a deadweight of 8200 tons. They are to be of steel construction, with a raked stem, double-knuckle stern, and two complete decks.

The propelling machinery is to consist of one set of three-unit, triple-expansion, condensing turbines, developing 6300 shaft horsepower, and operating a single propeller through reduction gearing. Steam is to be supplied at 325 pounds per square inch working pressure and 150 degrees superheat by four oil-fired watertube boilers. The speed of the vessels in loaded condition is to be 14 knots.

The vessels are to be built under the construction loan feature of the Merchant Marine Act of 1928, and will comply with the requirements of the Navy Department, for naval auxiliaries, and the Post Office Department, which has awarded a mail contract to the Export Corporation.

All the bids, with the exception of one, were considered on the basis of turbine drive with either superheaters, preheaters, or as specified. The Sun Shipbuilding Company submitted an alternative proposal to build the fleet of four vessels as Diesel-driven, twin-screw passenger vessels, with Sun-Doxford engines.

The bids received were as follows:

Name and Address		Price Each		Cost of Equipment (each)	Time (Months) 1	2	3	4
The Spear Engineers, Inc., Norfolk, Va.	1.	$1,990,750	(As Specified)	$87,070	18	22	26	30
	2.	1,986,500	(Double reduction gears)					
	3.	1,986,000	(General Electric Turbines)					
	4.	1,987,250	(DeLaval Turbines)					
	5.	1,987,750	(Fletcher Turbines)					
	6.	1,698,013	(Modified)					
Sun Shipbuilding & Drydock Company, Chester, Pa.	1.	2,146,000	(As specified)	67,000	15	19	23	27
	2.	2,360,000	(Sun-Doxford Diesel engines)					
Bethlehem Shipbuilding Corporation, Ltd., Bethlehem, Pa.	1.	2,158,000	(As specified)	89,500	18	24	30	36
	2.	2,127,000	(Modified)					
Federal Shipbuilding & Drydock Company, Kearny, N. J.	1.	2,250,000	(Foster boilers and air preheaters)	75,000	18	22	26	30
New York Shipbuilding Company, Camden, N. J.	1.	2,250,000	(As specified)	87,500	18	21	24	27
Newport News Shipbuilding & Drydock Co., Newport News, Va.	1.	2,587,000	(With economizers)	96,000	18	22	26	30
	2.	2,550,000	(With air preheaters)					
Maryland Drydock Company, Baltimore, Md.	1.	3,426,005	(As specified)	97,643	18	22	26	30
	2.	3,418,215	(Double reduction gears)					

The results of the bidding are as follows:

Name	Price 18 days	Price 12 days	Price Finished Nov. 24
Robins Drydock & Repair Company	$24,240	$24,920	$17,610
W. & A. Fletcher Company	24,000	27,384	21,440
Morse Drydock & Repair Company	26,241	26,681	19,545

Bids for Building Three Quarterboats Received

TENDERS were received recently at the United States Engineer Office, Vicksburg, Miss., for the construction of three wooden quarterboats, with the following results:

Name and Address	Price
Thos. M. Favre Gulfport, Miss.	$ 86,000
West Kentucky Coal Company Paducah, Ky.	92,000
Ayer & Lord Tie Company Chicago, Ill.	97,500
Howard Shipyards & Dock Company Jeffersonville, Ind.	100,125
Dubuque Boat & Boiler Works Dubuque, Iowa	120,000

The contract has not as yet been placed.

Contract for Repairs to M.S. Californian Awarded

THE Newport News Shipbuilding & Drydock Company, Newport News, Va., with the low bid of $20,793 and a time of 16 days was awarded a contract recently covering repairs to the American-Hawaiian Steamship Company's motorship *Californian*, which had been in collision with the steamship *Bogota* on the Delaware River off Chester, Pa. Bids for the work were received in the offices of Charles E. Ross, naval architect and marine engineer, 16 Exchange place, New York, N. Y., on Monday, November 12. Other bids received for the work were:

Name	Price	Days
Staten Island Shipbuilding Company	$24,390	15
W. & A. Fletcher Company	24,426	18
Robins Drydock & Repair Company	24,825	22
Sun Shipbuilding & Drydock Company	25,800	14
Tietjen & Lang Drydock Company	26,100	23
Morse Drydock & Repair Company	28,293	25
Bethlehem Shipbuilding Corporation, Ltd.	31,289	18

S.S. West Irmo to be Repaired at Robins Drydock

A CONTRACT for general repairs to the United States Shipping Board steamship *West Irmo* was awarded recently to the Robins Drydock & Repair Company, Brooklyn, N. Y. Bids for the work were recently received at the New York office of the board.

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U. S. Engineers Receive Tenders for Constructing Two Barges

THE United States Engineer Office War Department, Washington, D. C., recently received tenders for furnishing all labor and material and constructing and delivering afloat at the United States Engineer Wharf, Washington, D. C., two steel barges either of the usual plate and structural shape construction, referred to as Type A in the specifications, or of the patented Ellis Channel System of steel construction, referred to as Type B.

The barges are to have a length of 80 feet, breadth of 26 feet, depth of 6 feet (at side), and camber 3 inches straight taper in 13 feet.

The proposals submitted were as follows:

Name	Price
Atlantic Ellis Channel System, Inc.	$ 9,750
Bethlehem Shipbuilding Corporation, Ltd.	10,540
Dravo Contracting Company	11,500
Federal Shipbuilding & Drydock Company	12,745
J. S. Schofields & Sons	13,780
Newport News Shipbuilding & Drydock Company	13,950

No award has as yet been made.

Contract Awarded for Repairing Pile Driver No. S67

THE Raymond Concrete Pile Company, 140 Cedar street, New York, N. Y., has awarded a contract covering repairs to the pile driver *No. S67* to James Shewan & Sons, Inc., 32 Broadway, New York, N. Y., at a price of $14,794 and a time of 15 days. The work includes a general overhauling of machinery, painting the scow, and rebuilding the house. Four other bids were submitted for the work as follows:

Name	Price	Days
Todd Drydock, Engineering & Repair Corporation	$14,975	18
Robins Drydock & Repair Company	15,325	18
Staten Island Shipbuilding Company	15,475	18
Morse Drydock & Repair Company	15,995	16

Bids Received for Construction of Lighthouse Tender Althea

THE Department of Commerce, Bureau of Lighthouses, Washington, D. C., received tenders recently for the construction of a hull and auxiliary equipment for the tender *Althea*. The bids received were as follows:

Name and Address	Price	Calendar Days to Begin	Calendar Days to Complete
Bids for Hull			
New London Ship & Engine Company, Groton, Conn.	$50,950	10	210
Spear Engineers, Inc., Norfolk, Va.	65,000	10	280
Merrill-Stevens Drydock & Repair Company, Jacksonville, Fla.	69,000	10	150
Staten Island Shipbuilding Company, Staten Island N. Y.	82,900	5	180
Charleston Drydock & Machine Company, Charleston, S. C.	91,969	10	180 (working days)
Bids for Appendix "A"			
Winton Engine Company, Cleveland, Ohio	$13,000 $12,500 (alternate)	10	120
Bids for Appendix "B"			
Cummins Engine Company, Columbus, Ind. (General Electric generator)	$2772	10	90
(Ideal generator)	2650	10	50
Bids for Appendix "C"			
Worthington Pump & Machinery Corporation, 426 Homer Building, Washington, D. C.	$1388	..	9 weeks from receipt of order
Bids for Appendix "D"			
Lambert Hoisting Engine Company, Newark, N. J.	$2997	5	60
American Engineering Company, Philadelphia, Pa.	2550	..	12 weeks from receipt of order

No awards have as yet been made.

Contract Awarded for Repairs to S.S. Bogota

A CONTRACT for collision repairs to the Colombian Line steamship *Bogota* has been awarded to the Tietjen & Lang Drydock Company, Hoboken, N. J., at a price of $10,483 and a time of 10 days. Bids for the work were recently received at the offices of Frank S. Martin & Son, naval architects, 25 Broadway, New York, N. Y. The *Bogota* was recently in collision with the American-Hawaiian motorship *Californian* on the Delaware River, off Chester, Pa. Six other firms submitted tenders for the work as follows:

Name	Price	Days
W. & A. Fletcher Company	$10,700	13
Robins Drydock & Repair Company	11,585	11
Morse Drydock & Repair Company	11,995	12
Staten Island Shipbuilding Company	12,990	14
Sun Shipbuilding & Drydock Company	14,690	18
New York Harbor Drydock Company, Inc.	16,920	18

S.S. Galena to be Repaired By Sun Co.

A CONTRACT for general repairs to the steamship *Galena* was recently awarded to the Sun Shipbuilding & Drydock Company, Chester, Pa., by the Texas Company, 17 Battery place, New York city. Five tenders were submitted for the work as follows:

Name	Item 1	Days	Item 2	Item 3	Days
Sun Shipbuilding & Drydock Company	$45,714	36	$2995	$15,257	30
Robins Drydock & Repair Company	49,720	30	2840	17,409	9
Morse Drydock & Repair Company	51,116	39	3025	22,352	10
Newport News Shipbuilding & Drydock Company	57,600	55	3755	23,825	18
Staten Island Shipbuilding Company	58,753	40	3026	20,068	..

Price Bros. Plan Fleet of Motor Driven Barges

PRICE Brothers of Montreal are planning to operate a fleet of motor-driven steel barges on Lake Champlain and the Champlain division of the barge canal for the purpose of carrying newsprint paper from Montreal to New York city. It is understood that the boats will each have two semi-Diesel engines, and will be 110 feet long, with a beam of 30 feet.

Todd Pulverized-Coal Burner Proves Efficient in Tests

ON November 13, a group of representative shipowners and operators, together with members of the fuel conservation committee of the United States Shipping Board, visited the fuel-oil testing plant at the League Island Navy Yard, Philadelphia, Pa., for the purpose of witnessing the tests made on the Todd pulverized coal-burners developed by the Todd Dry Dock Engineering & Repair Corporation, Brooklyn, N. Y. The official tests on this new type pulverized-coal burner have effectively demonstrated the application of individual pulverizing mills for each burner.

Up to this time all experimentation has been confined to the burning of pulverized coal in the furnaces of Scotch marine boilers, marine engineers generally conceding that this was the most difficult condition to meet. With this condition successfully met, the aim was to develop an apparatus that would have a universal application regardless of whether the present fuel being burned was oil or coal on the grate. It was held in mind that the cost of the apparatus and its installation, together with its weight and bulk and simplicity of operation, were all features of vital importance to the ship operator and owner. In comparison with systems heretofore used aboardship, there is a very decided difference in weight in favor of the Todd system.

The apparatus which was finally developed and used in the tests is a remarkably simple machine, consisting of a motor or turbine-driven impact mill with two stages of pulverization, containing a fan to furnish primary or carrying air, and feeding apparatus to regulate the amount of coal going into the mill. The equipment is very compact and rugged. A complete unit is installed on each furnace front. The flexibility of such an installation is an outstanding feature since it now becomes possible to operate all fires independently.

The burners demonstrated were applied to a regular form of Howden forced-draft front, with only such changes to the front itself as are usually made when changing from coal to oil burning and the secondary air coming from the Howden fan was approximately of the same pressure as used when burning coal on the grate. This permits the use of the same draft fan and ducts as exist in the ship and does not destroy the usual coal-on-the-grate operation.

The capacity of the burners demonstrated has been shown to be from 200 pounds to 600 pounds per hour per burner, this range is well within the requirements usually found for a Scotch boiler furnace.

The grade of coal burned during these tests had a B.t.u. value of about 14,000. Due to the fineness of pulverization and the completeness of combustion there has been no ash trouble as most of the ash is fine enough to pass with the gases through the stack.

The consensus of opinion of the visitors and engineers in charge of the test, indicates that excellent combustion conditions were obtained and that the overall efficiency of the burner and boiler exceeded expectations.

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Lectures on Streamline Rudders Given at Webb Institute

A JOINT lecture on streamline rudders was presented at the Webb Institute of Naval Architecture, New York, N. Y., on Friday, November 2, 1928. N. J. den Tex, chief engineer of the Oertz Streamline Rudder Corporation, New York, N. Y., explained the theory of the Oertz rudder, which is based on the aerodynamic principles of aviation. This theory was followed by illustrations of installations showing the methods employed in both remodeling plate rudders and constructing rudders for new ships.

This lecture was followed by a similar address given by J. Livingston, secretary and manager, engineering department of Th. Goldschmidt Corporation, New York, N. Y. In dealing with the contra-propeller and contra-rudder, Mr. Livingston states that, "The main object of the contra-propeller is to regain part of the propeller losses. The screw propeller, in revolving, sets a large volume of water rotating and this absorbs a considerable amount of power which is lost as far as the propulsion of the vessel is concerned. The function of the contra-propeller is to change the rotary motion of the propeller jet and guide it, without shock, in a straight, rearward stream. In thus being deflected, the water mass gives back a large part of the energy that otherwise would be lost by reacting on the contra-propeller blades and imparting thereby additional forward thrust in the direction of motion of the ship."

A tabulation of the data obtained at the Washington Model Basin with a self-propelled model of the five new Coast Guard cutters now under construction at the Bethlehem Shipbuilding Corporation, Fore River, Mass., is given in Table 1. Three different rudder arrangements were tested, namely, a single-plate rudder, symmetrical streamline rudder and a contra-rudder.

Fig. 2 shows the contra-propeller and contra-rudder installed on one of these cutters. The rudder consists of a cast-steel frame to which is welded the side plates. The contra-propellers in this case were made of castings attached to the rudder post which was specially designed for this purpose.

TABLE 1.—COMPARISON BETWEEN PLATE RUDDER, SYMMETRICAL STREAMLINE RUDDER, AND CONTRA-RUDDER

Speed in knots	S.H.P. Plate Rudder	S.H.P. Streamline Rudder	S.H.P. Contra-Rudder	Percent Reduction in S.H.P. Streamline Rudder	Percent Reduction in S.H.P. Contra-Rudder
9	400	370	320	7.5	20.0
10	560	520	440	7.2	21.4
12	960	900	790	6.25	17.7
14	1580	1480	1320	6.3	16.5
15	2640	2400	2200	9.1	16.7
17	3580	3200	3000	10.6	16.2

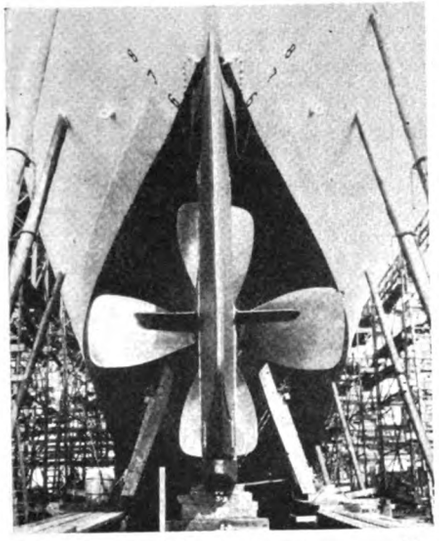

Fig. 2.—Installation of contra-propeller and contra-rudder on one of the five United States Coast Guard cutters

Cox & Stevens Design Yacht for Harrison Williams

INFORMATION has been received that Cox & Stevens, naval architects, 347 Madison avenue, New York city, are designing a yacht for Harrison Williams of New York city. Although definite details are not known at the present time, it is said that the vessel will have a length of approximately 500 feet

New Names for Vessels of American Export Lines

THE following list shows the old and new names of all vessels owned and operated by The Export Steamship Corporation, New York, at the present time:

Old Name	*New Name*
Blair	*Exchange*
Blue Triangle	*Exmouth*
Carenco	*Executive*
City of Eureka	*Explorer*
City of St. Joseph	*Extavia*
Clontarf	*Exermont*
Coeur D'Alene	*Examelia*
Corson	*Exiria*
Half Moon	*Exanthia*
Hog Island	*Express*
Liberty Land	*Excellency*
Luxbalile	*Excello*
Nobles	*Exmoor*
Ossa	*Exbrook*
Sangamon	*Exton*
Saucon	*Exhibitor*
Saugus	*Exminster*
Sinsinawa	*Examiner*
The Lambs	*Exporter*
Winona	*Exchester*
West Carnifax	*Exford*
Naamhok	*Exarch*

American Port Officials to Inspect European Harbor Facilities

A COMPREHENSIVE inspection trip of the major ocean and inland harbors of Europe has been arranged for American port and harbor officials, who will sail from New York on April 20.

The inspection tour will include England, Holland, Germany, Belgium and France.

A committee has been formed to aid in developing interest in the visit and is composed of the following members:

R. S. MacElwee, chairman, Commissioner Bureau of Port Development, Charleston, S. C.; J. Spencer Smith, president, New Jersey State Board of Commerce and Navigation; S. A. Thompson, secretary of the Rivers and Harbors Congress; Major Daniel I. Sultan, resident member of the Board of Engineers for Rivers and Harbors; Major L. R. Lohr, editor *Military Engineer*; George F. Nicholson, harbor engineer for the City of Los Angeles; C. H. Newman, secretary of the Society of Terminal Engineers; and Edward G. Eichelberger, secretary for the group.

Supply Trade

Business and Personal

John A. Manley, manager of sales development of **Fairbanks, Morse & Co.**, Chicago, has been elected vice-president in charge of sales. He graduated from

John A. Manley

Northwestern University in 1911 and entered the sales department of the Republic Tire & Rubber Company. In 1915 he joined the advertising staff of one of the Chicago newspapers and later entered the employ of Hart, Schaffner & Marx. He resigned from this position to become manager of accounts of Henri, Hurst & McDonald, Chicago, and in 1925 became associated with Fairbanks, Morse & Co. as manager of sales, which position he has held until his recent election.

The **Prest-O-Lite Company, Inc**, New York city, has announced the addition of a new acetylene plant to its chain of 35 producing factories. This plant, located at South Charleston, W. Va., is under the direct management of **J. J. Robinson. S. P. Murphy,** whose headquarters are at Cincinnati, O., is district superintendent.

The **De La Vergne Machine Company,** which recently moved its plant and general offices from New York city to Philadelphia, Pa., still maintains a large staff at the New York city branch offices, 100 Broadway.

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James A. Smith, superintendent of the Schenectady plant of the **General Electric Company** for the last 15 years, died October 25 at his home in Schenectady, N. Y.

Mr. Smith was born in Hartford, Conn., May 25, 1873. In 1888 he

James A. Smith

entered the employ of **Pratt and Whitney,** Hartford, Conn., and in 1901, he was associated with the **Niles-Bennett Company** of New York. In 1905, Mr. Smith became superintendent of the **Duchess Tool Works** at Fishkill Landing, which position he retained until he became assistant to the mechanical superintendent at the Schenectady plant of the **General Electric Company,** in 1910.

The **Kennedy-Van Saun Company of Illinois,** 120 South La Salle street, Chicago, Ill., has been established as a subsidiary of the **Kennedy-Van Saun Manufacturing & Engineering Corporation,** New York city. **T. J. Shearer** has been appointed manager in charge of the Chicago branch.

The **Diesel Society of America, Inc.,** announces the election of the following officers: **Julius Rosbloom,** general president; **Richard A. Meyer,** general vice-president and **Walter Knudsen,** general secretary. The executive offices are located at 26 Court street, Brooklyn, N. Y.

T. E. Barnum, chief engineer of the **Cutler-Hammer Manufacturing Company,** Milwaukee, Wis., has been appointed consulting engineer and will be succeeded by **N. L. Mortenson,** assistant to the chief engineer.

Harold C. Osman, secretary of the **Nugent Steel Casting Company,** Chicago, Ill., and heretofore in charge of sales for that company, was recently appointed works manager.

F. Edward O'Neil was recently appointed vice-president and manager of the **Fulton Iron Works Diesel division,** with headquarters at St. Louis, Mo.

Trade Publications

HYDRAULIC VARIABLE SPEED GEARS.—**The** Waterbury Tool Company, Waterbury, Conn., has distributed three catalogues Nos. 110, 111 and 112, in which the uses of the Universal hydraulic, variable-speed gear are described. Catalogue 111 gives a detailed description of the construction while catalogue 110 deals with its application to the marine problems of steering gears; catalogue 112 deals with the application of the gear to deck auxiliaries. This gear is also suitable for capstans, winches, boat hoists and derricks.

SINGLE PHASE MOTORS.—The Wagner Electric Corporation of St. Louis, Mo., has issued a new bulletin describing the Wagner large RA single-phase, repulsion-induction motors. The bulletin is well illustrated and contains detailed descriptions of every part of the motor. Such subjects as the types of single-phase motors, the history of repulsion-induction motors, operating principles, sleeve and ball-bearing construction and ventilation are covered.

ALLOY STEELS.—A reprint of an article from the *Iron Trade Review* has been distributed by the Vanadium Corporation of America, New York City. This article, entitled "Manufacturers' Research Broadens Use of Alloy Steels," by Herbert R. Simonds, deals with the increasing popular demand for the use of Vanadium in improving the quality of steels in all branches of industry.

HEAT TREATMENT.—"Electric Heat in General Electric Factories" is the subject of a descriptive booklet issued by the General Electric Company, Schenectady, N. Y. This booklet illustrates the methods employed by the General Electric Company in the heat treatment of electrical apparatus.

MARINE HEATERS.—"Reilly Marine Heaters" and "Reilly Evaporators" are the subjects of two loose-leaf catalogue inserts distributed by the Griscom-Russell Company, New York city. Form No. 429 deals with the installation of marine heaters; four typical layouts are illustrated in the sheet, showing both the single-pass and the two-pass Reilly heater with the induction and thoroughfare types of installation; form 447 gives instructions for installation and operation of the Reilly evaporator plant. A diagrammatic layout of the evaporator plant is given together with instructions for blowing down and automatic scaling.

STEAM PURIFIERS.—"The Wet Steam Problem—How to Solve It" is the subject of a booklet published by the Hagan Corporation, Pittsburgh, Pa. The use of the Hagan centrifugal steam purifier is suggested for the solution of this problem. A detailed description of the purifier together with reasons for its effectiveness and a description of its operation are given. Illustrations of numerous types of installations complete the booklet.

NICKEL STEEL.—A pictorial review of progress in the use and applications of nickel steel in various industries has been issued in the form of a leaflet by the International Nickel Company, New York city. Fourteen applications of nickel-alloy steel are illustrated. These applications cover marine, automotive and other miscellaneous installations.

Marine Societies

America

American Marine Association, 30 Church St., New York. President—Col. E. A. Simmons.

American Marine Standards Committee. Chairman, Colonel E. A. Simmons. Secretary, A.V. Bouillon, Division of Simplified Practice, Department of Commerce, Washington, D. C.

American Society of Marine Designers. Secretary—B. G. Barnes, 202 Kendrick Ave. Quincy, Mass.

American Society of Marine Engineers. 605 Market St., San Francisco, Calif. President—James Bullock. Secretary—W. H. Thille.

American Society of Naval Engineers. Navy Department, Washington, D. C. Secretary and Treasurer—Captain O. L. Cox, U. S. N., Bureau of Engineering, Navy Department, Washington, D. C.

American Steamship Owners' Association, 11 Broadway, New York. President—H. B. Walker.

Jersey Marine Club, 4th and River Streets, Hoboken, N. J. Secretary—Fred L. Broad.

Lake Carriers' Association. President—J. S. Ashley. Secretary—George A. Marr, Rockefeller Building, Cleveland, O.

National Association of Engine and Boat Manufacturers, 420 Lexington Avenue, New York City. Secretary—Ira Hand.

National Association of Masters, Mates and Pilots. National Secretary—M. D. Tenniswood, 308 Vine St., Camden, N. J.

National Council of American Shipbuilders, Inc., 50 Broadway, New York. President—Homer L. Ferguson. Secretary-Treasurer—Henry C. Hunter.

National Marine Engineers' Beneficial Association. Headquarters 311-315 Machinists Building, Washington, D. C. President—Wm. F. Yates. Secretary—Albert L. Jones.

Neptune Association, 21 Pearl St., New York City. Secretary-Treasurer—Captain John F. Milliken.

New York and New Jersey Dry Dock Association. 111 Broadway, New York. President Jonathan Moore.

Ocean Association of Marine Engineers. 15 Whitehall St., New York. Secretary—Bert L. Todd.

Port of New York Authority, 75 West Street, New York. Chairman—George S. Silzer. Secretary—Wilson J. Vance.

Society of Naval Architects and Marine Engineers, 29 West 39th Street, New York. Secretary and Treasurer—Daniel H. Cox.

The Maritime Association of the Port of New York, 78 Broad St., New York City. President—John Dowd. Secretary—John F. Manning.

The New York Tow Boat Exchange, 11 Moore St., New York. Manager—Langdon W. Smith.

The Propeller Club of the Port of New York. President—E. M. Roberts, New York. Secretary—W. Z. Gardner, 136 Liberty Street, New York.

United States Naval Institute. Naval Academy, Annapolis, Md. Secretary and Treasurer—Captain H. A. Baldridge, U. S. N.

United States Ship Operators' Association, 149 Broadway, New York. President—Winchester Noyes.

Canada

Grand Council N. A. of M. E. of Canada. Grand Secretary-treasurer—W. A. MacDonald, 62 Albert St., Halifax, N. S.

Great Britain

Institute of Marine Engineers Incorporated, 85-88 The Minories, London E.1.

Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow.

Institution of Naval Architects, 2 Adam Street, Adelphi Terrace, London, W. C.

North East Coast Institution of Engineers and Shipbuilders. Bolbec Hall, Westgate Road, Newcastle-on-Tyne.

France

Association Technique Maritime et Aëronautique. Secrétariat Genéral—7, rue de Madrid, Paris (8e).

Italy

Collegio Degli Ingegneri Naval e Meccanici In Italia.

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